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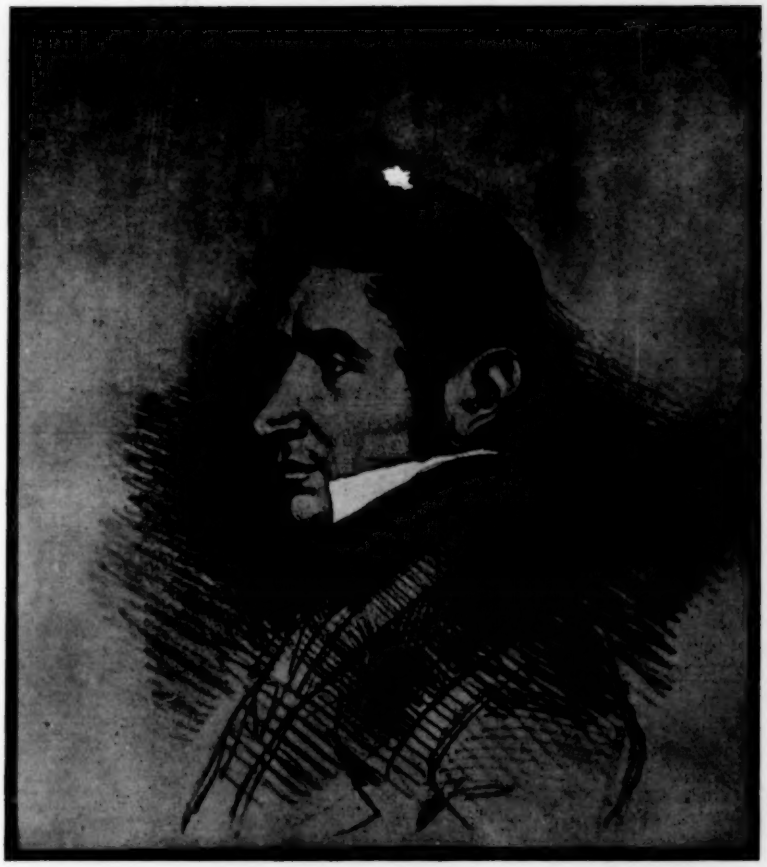
Preface to Volume XXIII of Isis (Quetelet)

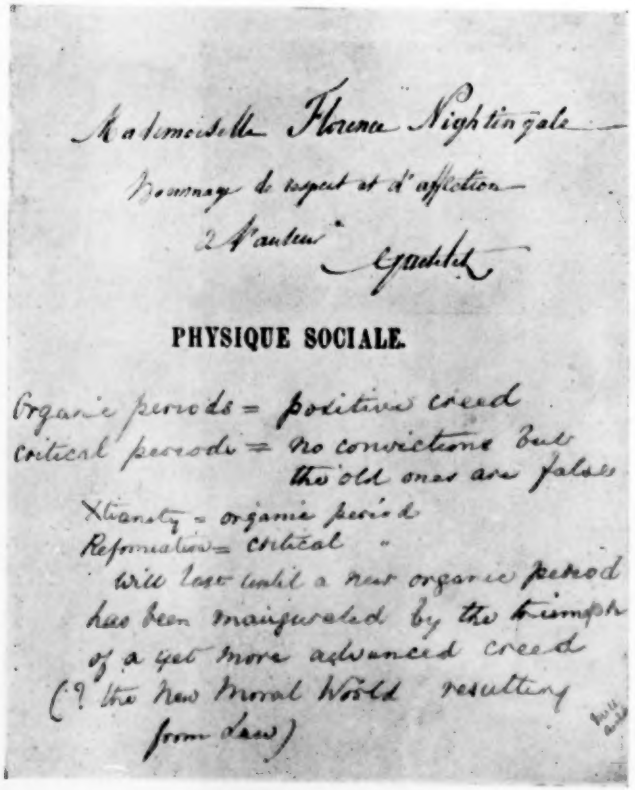
Among the many centenaries to be celebrated in 1935 none appeals to my imagination more strongly than that of the publication of QUETELET's work entitled "*Sur l'homme et le développement de ses facultés, ou Essai de physique sociale*" (1), one of the greatest books of the nineteenth century. The world would be better today if more politicians and administrators were trained to understand QUETELET's message, but the intellectual inertia of the so-called leaders as well as the stupidity of their flocks brings into greater prominence the genius of such men as himself and GALTON. QUETELET's book on man and the development of his faculties with the bold subtitle SOCIAL PHYSICS was the first attempt to apply mathematical analysis to the study of man—not only of his body but of his behaviour and morality, his mind and soul. The book made a considerable stir in Europe, the original Paris edition being soon followed by a pirated one (Brussels, 1836), by German and English translations (Stuttgart, 1838, Edinburgh, 1842) and by abundant and acrimonious controversies. A small minority recognized its prophetic value, but for the mass of the educated people it was rather a cause of scandal and grief. How could anyone carry scientific indiscretion and impiety further than by attempting, as QUETELET did, to analyse man's transgressions as if they were physical accidents, to consider the passions of his soul as if they were abnormalities of the weather, and his very morality as a kind of climate? QUETELET's "average man" was ridiculed and tabooed.

(1) 2 Vols., 21 × 13 cm., XII+327 p., 2 tables, VIII+327 p., 6 tables (Paris, 1835). Fig. 5.



Isis, XXIII, pl. 1. PLATE 1, FIG. 1. G. SARTON

QUETELET's portrait drawn in charcoal, about 1835 (see Appendix).



Mademoiselle Florence Nightingale

Hommage de respect et d'affection

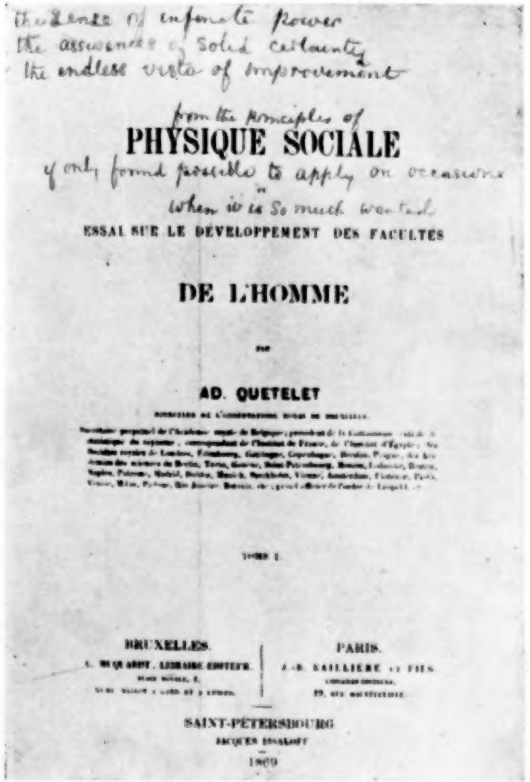
de l'auteur

Quetelet

PHYSIQUE SOCIALE.

Organic periods = positive creed
critical periods = no convictions but
the old ones are false

Xtianity = organic period
Reformation = critical "
will last until a new organic period
has been inaugurated by the triumph
of a yet more advanced creed
(? the New Moral World resulting
from Laws)



the sense of infinite power
the assurance of solid certainty
the endless vista of improvement

from the principles of

PHYSIQUE SOCIALE

if only found possible to apply on occasions
as
when it is so much wanted

ESSAI SUR LE DÉVELOPPEMENT DES FACULTÉS

DE L'HOMME

PAR

AD. QUETELET

TOME I.

BRUXELLES. | PARIS.

SAINT-PÉTERSBOURG

1869

Isis, XXIII, pl. 2. FIG. 2. FIG. 3. G. SARTON

Title-pages of the copy of the *Physique sociale* presented to FLORENCE NIGHTINGALE (see Appendix).

Yet QUETELET had proved his case as completely as it was possible to prove it in his own time and with the means at his disposal. If the average number of crimes, suicides, births out of wedlock, etc. are constant in a given community, one cannot escape the conclusion that they must needs reveal realities comparable to physical realities, and that the most secret behaviour of men is submitted to social laws of the same kind as the laws of physics. Whichever might be the idiosyncrasies and the freedom of individuals, their average morality and behaviour could be foretold as well as their average physical features and longevity. Moreover he showed that inasmuch as it is hopeless to study each and every individual, the only approach to social physics or sociology was the mathematical analysis or the statistical method to the explanation and illustration of which his book was devoted.

The statistical instrument is to the sociologist and statesman what the thermometer is to the physician; if one knows the data relative to a body politic presumably sound, the anomalous data relative to another body will reveal its illness. The physician observing an abnormal temperature knows that something is wrong; his next tasks are to locate the cause of the illness and find a remedy. So does the statistician who observes excessive rates of murder or suicide or sexual delinquency in a given community. He knows that there is something wrong, and such knowledge is the first condition of redress. Again, if he should observe that the inequalities of wealth and opportunity are excessive—that the rich are too rich and too few and the poor too poor and too many—he knows that the body politic of that particular community is not well. However the majority of men are conscious or unconscious hypocrites; they are far more afraid of the publication of evil than of evil itself; and if they enjoy privileges which would not bear scrutiny they prefer darkness to light. Such people are very apt to mistake their own selfish interests for those of the community, to resent the diagnosis of a disease on which they have managed to thrive, and to browbeat the physician who exposes the evil and attempts to cure it.

Far from being a sacrilege, the search and revelation of truth is a duty,—it is not simply a scientific duty in a narrow sense, it is also a philanthropic duty and a religious one. The religious —or if you please the mystical—aspect of statistical inquiries

was strongly evidenced in one of the earliest treatises on the subject, the one published almost two centuries ago by JOHANN PETER SÜSSMILCH (1707-67), entitled *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts* (2 vols., Berlin, 1741, fig. 4) (2). It was beautifully expressed by that great woman, FLORENCE NIGHTINGALE (1820-1910), " The Lady of the Lamp "—According to PEARSON's account (3) :

" Her statistics were more than a study, they were indeed her religion. For her, QUETELET was the hero as scientist, and the presentation copy of his *Physique sociale* is annotated by her on every page (4). FLORENCE NIGHTINGALE believed —and in all the actions of her life acted upon that belief—that the administrator could only be successful if he were guided by statistical knowledge. The legislator —to say nothing of the politician—too often failed for want of this knowledge. Nay, she went further : she held that the universe—including human communities—was evolving in accordance with a divine plan; that it was man's business to endeavour to understand this plan and guide his actions in sympathy with it. But to understand God's thoughts, she held we must study statistics, for these are the measure of his purpose. Thus the study of statistics was for her a religious duty."

* * *

QUETELET's book of 1835 had been prepared by statistical studies initiated ten years earlier. His golden age was probably the decade beginning in 1828. In that year he published his *Instructions populaires sur le calcul des probabilités*—one of the earliest popularizations of a subject of which relatively few people realized the fundamental importance in those days, and he read his memoir " *Recherches statistiques sur le Royaume des Pays-Bas* " (5), in the preface of which he clearly expresses the value of comparative statistics for the diagnosis and understanding

(2) I have seen only a later edition (3 vols., Berlin, 1761-76). Vols. 1-2 (1761-2) are a second edition; vol. 3 (1776) an additional volume by CHRISTIAN JACOB BAUMANN.

(3) KARL PEARSON : *The life, letters and labours of* FRANCIS GALTON (vol. 2, 414, Cambridge, 1924; *Isis* 8, 186). See also our figs. 2 and 3, and appendix.

(4) Presented to the Galton Laboratory by Miss NIGHTINGALE's niece, Mrs. VAUGHAN NASH, and now placed beside DARWIN's gift of the *Origin of species* to GALTON and TYNDALL's gift of his Belfast address to HERBERT SPENCER. (K. P.)

(5) Read before the Royal Academy of Brussels on Dec. 6, 1828. *Nouveaux mémoires de l'Académie royale* (tome 5, 29-57, 12 tables, Bruxelles, 1829).

of social conditions. In 1835—the golden year—appeared his *Social physics*, wherein his conviction was reiterated and bolstered up with a great variety of examples. A couple of years later the first king of the Belgians, LEOPOLD I, invited him to give some lessons to two princes of his family—ERNEST and ALBERT OF SAXE-COBURG—during their stay in Brussels. These letters were eventually published under the title, *Lettres sur la Théorie des probabilités appliquées aux sciences morales et politiques* (454 p., 26 × 17 cm., Bruxelles, 1846, fig. 6). GALTON who studied them in the English translation (London, 1849) considered them " the most suitable [treatise on the subject] to the non-mathematical reader " (6). When EULER wrote his famous letters for the niece of FREDERICK THE GREAT, the Princess of Anhalt-Dessau (Petersburg, 1768) he did not speak of the calculus of probabilities though it was already fairly advanced in his day. It is much to the credit of QUETELET and of his royal patron that that calculus and its applications to the social sciences were now considered a fit subject for a ruling prince. Indeed could one imagine one more fit to give the latter some idea of his responsibilities? And yet I wonder how many of the remaining princes of our own days realize this as deeply as they should?

GALTON (7) was not entirely fair to QUETELET when he said that the latter had not fulfilled the high promise contained in his work of 1835. It is true the second edition of the *Social physics*, was not materially different from the first, though it appeared thirty-four years later (8), but this was partly due to the fact that his genius had already reached its highest potential in 1835. The rest of his life was devoted not to any attempt to soar higher, or to undertake new explorations in the unknown, but rather to the consolidation of his initial effort. He was the leading spirit not only of the Observatory and the Academy of Belgium, but of almost every scientific endeavour in the new kingdom, and in addition to that he was the prime organizer

(6) Needless to say that book is now obsolete if only because there is no mention in it of the theory of correlation, first published by GALTON in 1888. PEARSON: *Life of* GALTON (vol. 2, 335, 1924; vol. 3, 50, 1930; *Isis* 22, 253-5).

(7) PEARSON (vol. 2, 420; *Isis* 8, 186).

(8) *Physique sociale* was now the main title. " *Physique sociale, ou Essai sur le développement des facultés de l'homme* (2 vols., Bruxelles, 1869). See figs. 2, 3.

of every international agency for meteorological and statistical investigations. He was one of the founders of the London (Royal) Statistical Society in 1834 (9) and when the American Statistical Association was founded five years later, he was its first foreign member. He was the creator of the international congress of statistics, and his unchallenged supremacy is proved by the circumstance that out of the nine congresses (10) he presided over seven! He was president of the first congress in Brussels 1853, of the third, Vienna, 1857, of the fourth, London, 1860, of the fifth, Berlin, 1863, of the sixth, Florence, 1867, of the seventh, The Hague, 1869, of the eighth, Petersburg, 1872 (I do not believe there is another example in the history of international scientific congresses of such a persistent leadership). He failed to preside over the second congress (Paris, 1855) because he had an apoplectic stroke in July of that year, and over the ninth (Budapest, 1876), because of his death (11). He was truly the father—or we might say the patriarch—of statistics.

***

At this point I beg leave to open a parenthesis for the sake of refuting a common error. It is often said, and not only by Germans, that the father of statistics was ACHENWALL. This is not simply erroneous but highly misleading. Far from being the father of statistics, GOTTFRIED ACHENWALL (1719-72) did not even know what statistics is. He may have been the first to speak of statistics, but he really spoke of something very different from what we understand by that word. I have examined his *Abriss der neuesten Staatswissenschaft der vornehmsten Europäischen Reiche und Republicken* (x+324 p., Göttingen, 1749). This is simply a brief description of the countries of Europe with special reference to their constitution, products, character and qualities

(9) The centenary of which was celebrated this year. See *Nature* (133, 560, 1934).

(10) The congresses were replaced in 1885 by a permanent organization, the International Statistical Institute. JOHN KOREN: *The history of statistics* (New York, 1918; *Isis* 4, 387-9).

(11) He was born in Ghent on February 22, 1796, and died in Brussels on February 17, 1874. Good biography by EMILE WAXWEILER in *Biographie nationale de Belgique* (18, 477-94, 1905).

of the inhabitants, laws, commerce, etc. The purpose is comparative, but no special chapter is devoted to a comparative survey of each of the elements dealt with in the other chapters. Numbers are seldom in evidence, and there are neither numerical tables nor graphs of any kind! As far as I could make out the statistical contents of this book are not essentially different from those which may be found in many other publications which began to appear two centuries earlier, such as SEBASTIAN MÜNSTER's *Cosmographia* (1536, 1544), GIOVANNI BOTERO's *Relazioni universali* (1596), etc. Indeed statistics in that early sense is as old as almost any form of organized society, for has not every intelligent ruler (whether he be the king *gratia Dei* of a very elaborate commonwealth or the chieftain of a barbarian tribe) the wish to know as exactly as possible the amount of his resources in men and goods, and to know equally well the resources of his possible allies and enemies? Any systematic attempt to satisfy such curiosity was " statistics " in the old sense (12).

ACHENWALL begins his Abriss with the following words : " Der Begriff der sogenannten Statistic [sic], das ist, der Staatswissenschaft einzelner Reiche wird sehr verschiedentlich angegeben, und man trifft unter der grossen Menge Schriften davon nicht leicht eine einzige an, welche in der Zahl und Ordnung ihrer Theile mit der andern überein kommen sollte "... This shows that by the middle of the eighteenth century the exact contents of the new science called " statistics " was not yet clearly understood in spite of its popularity; however it might be broadly defined as " a comparative study of states." It is often said that ACHENWALL was the first to use the word statistics (13), but I am not sure even of that for if he had coined the term would he say " die sogenannte Statistic "?

The roots of QUETELET's thought must be sought outside of that " so-called statistical " literature. There are two main roots.

(12) To illustrate, consider Egypt. For what might be called the statistical organization of the old Empire (c. 3400 to c. 2475), see ADOLF ERMAN and HERMANN RANKE : *Aegypten* (Tübingen, 1923, 107). For the general census under the XVIIIth dynasty (1580-1350), see SERGE DAIRAINES : Un socialisme d'état quinze siècles avant J. C. (Paris, 1934, 75). Consider also Israel : read Chs. 1 to 4 of the *Book of Numbers*.

(13) E.g., LITTRÉ's *Dictionnaire* s.v. statistique. The earliest English example given in MURRAY's *NED* is ZIMMERMANN, 1787.

First, the " political arithmetic " which developed in England in the second half of the seventeenth century; second, the calculus of probabilities which originated about the beginning of the same period (1654) in a correspondence between PASCAL and FERMAT, and reached a magnificent climax in LAPLACE's *Théorie analytique des probabilités* (Paris, 1812). LAPLACE lived until 1827. QUETELET was deeply influenced by him, and was introduced to him in Paris, in 1823 (14). I shall not insist on the history of the theory of probability for that is too beautiful a story to be told in a hurry (15) but I may say a few more words of the political arithmeticians who illustrated so remarkably in this regard the English genius for concrete explanations.

These were Captain JOHN GRAUNT (1620-74) and Sir WILLIAM PETTY (1623-87). The first prepared the *Natural and political observations upon the bills of mortality* (London, 1662, fig. 7), then PETTY published a series of tracts on " political arithmetic " and " political anatomy "—and finally his famous treatise entitled *Political Arithmetick*, which he wrote as early as 1676-77. This was published surreptitiously in 1683, but the first duly licensed edition appeared only in 1690 after the author's death (16). A third great forerunner was EDMUND HALLEY (1656-1742), whose

(14) QUETELET had a good mathematical training and began his scientific career as a teacher of mathematics. He and JEAN GUILLAUME GARNIER started in 1825 the publication of a journal entitled *Correspondance mathématique et physique* (11 vols., Ghent 1825-39) which was of great importance for the mathematical education of Belgium. After its discontinuance in 1839, there was no mathematical journal in that country until 1874 when EUGÈNE CATALAN and PAUL MANSION started the *Nouvelle correspondance mathématique*. From 1876 to 1880 CATALAN was the only leader and raised the mathematical standard of his journal very high, perhaps too high for the rank and file. In 1881, it was replaced by *Mathesis*, the aim of which was more modest; *Mathesis* was originally edited by P. MANSION and J. NEUBERG; it is still going strong today.

To return to GARNIER and QUETELET's journal, it is significant that in spite of its elementary character (that is, the purpose was rather the diffusion of knowledge than original research) it included many statistical notes; it thus helped to popularize the statistical point of view.

(15) Read ISAAC TODHUNTER : *History of the mathematical theory of probability from the time of* PASCAL *to that of* LAPLACE (640 p., Cambridge, 1865). HELEN M. WALKER : *Studies in the history of statistical method* (338 p., Baltimore, 1929; *Isis* 13, 382-3).

(16) Lord EDMOND FITZMAURICE (*DNB*, 45, 113-9, 1896). The only perfect copy of the unauthorized edition of 1683 is in the Bodleian Library. See figs. 10, 11.

endless curiosity and brilliant mind were once more exemplified in a paper of his containing the earliest mortality table " An estimate of the degrees of the mortality of mankind, drawn from curious tables of the births and funerals at the city of Breslaw, with an attempt to ascertain the price of annuities upon lives " (*Philosophical Transactions* for January 169⅝, vol. 17, No. 196, p. 596-610, fig. 8). HALLEY's interest in statistics went back at least to 1681 (17). SÜSSMILCH, mentioned above, continued the English political arithmetic in a more mystical vein. It now became the mathematicians' business to keep this movement on the right track. The main difficulty as always was to fight off the theologians and philosophers who had no patience for austere investigations and were more anxious to know or to prattle as if they knew, than to study. QUETELET quoted approvingly JOSEPH FOURIER's saying " Les sciences statistiques ne feront de véritables progrès que lorsqu'elles seront confiées à ceux qui ont approfondi les théories mathématiques." (*Correspondance mathématique*, 2, 177, Gand, 1826). FOURIER's warning is still necessary to-day.

The victory of the political arithmeticians and even more so that of the theorists of probability was so overwhelming that the meaning of the word statistics changed radically, almost without anybody being aware of how, when and why. The emphasis had been gradually transferred from the subject to the method. Statistics was no longer restricted to the description of states; it was applied to the study of any collection of facts which could be summarized in the form of tables, curves and graphs. It is now defined " The science of the collection and classification of facts on the basis of relative number or occurrence as a ground for induction; systematic compilation of instances for the inference of general truths; doctrine of frequency distributions " (18). Statistical training is focused upon the theory of probability and its applications to any problem which life or science may suggest. It concerns itself with such questions as the definition of averages, the appreciation of the homogeneity of collections, the

(17) See his letter to HOOKE, May 19/29 1681. and also his letter to CASPAR NEUMANN of Breslau, 1693, quoted in EUGENE FAIRFIELD MACPIKE : *Correspondence and papers of* EDMOND HALLEY (Oxford, 1932, 52, 89; *Isis* 20, 470-2).

(18) Definition of the word statistics (construed as singular) in WEBSTER's *New International Dictionary*. (2d. ed., 1934).

best means of sampling them, the interpretation of the data with a minimum of distortion or error. ACHENWALL had neither knowledge nor conception of these matters. On the contrary, QUETELET was keenly aware of them, and realized their complexity, difficulty, and fundamental importance.

* * *

Another great injustice is made when COMTE is called the founder of sociology, for QUETELET has better claims to this title than he, or at least they should be mentioned together. AUGUSTE COMTE (1798-1857) was probably the first to speak of social physics (as early as 1822) and of sociology (1839) (19). In 1824, he wrote to a friend " Je crois que je parviendrai à faire sentir, par le fait même, qu'il y a des lois aussi déterminées pour le développement de l'espèce humaine que pour la chute d'une pierre."(20) COMTE wrote on these matters as on many others with unbearable prolixity and conceit. In the meanwhile QUETELET was not only saying what to do, but was actually doing it, and doing it much better than COMTE could imagine, for the real difficulties and the crucial points only appear when one is tackling concrete problems and tackling them in large numbers humbly and patiently; they remain almost always hidden from the superficial and supercilious minds of philosophers. COMTE talked, strutted and soared, and apparently ignored the terre-à-terre activity of his fellow worker in " social physics " (21), but that activity was far more creative than his own. COMTE was building proud castles on sand, QUETELET, humbler constructions on bedrock. Moreover COMTE had no appreciation of the importance of the theory of probability, nor of statistics, nor of the statistical approach to biology and sociology (22). I do not propose to discuss the question " who was the founder of sociology ? "—but

(19) *Cours de philosophie positive* (Tome 4, 252, 1839).

(20) In a very long letter dated Sept. 8, 1824. *Lettres d'*AUGUSTE COMTE *à* M. VALAT (Paris, 1870, p. 139).

(21) I do not remember any reference to QUETELET in COMTE's works, but have read them only in parts and at different times. The Comtian literature is very extensive and unindexed. At any rate QUETELET is not mentioned at the very places where one would expect at least a mention of his name.

(22) See his silly remarks in the *Cours de philosophie positive* (vol. 3, 410 ff., 418).

Die göttliche

Ordnung

in den Veränderungen

des menschlichen Geschlechts,

aus

der Geburt, Tod, und Fortpflantzung

desselben

erwiesen von

Johann Peter Süßmilch,

Prediger beym hochlöblichen Kalckstenischen Regiment.

Nebst einer Vorrede

Herrn Christian Wolffens.

Verschieden
Berlin,
Zu finden bey J. C. Spener. V.f. v. 24.6.191

1741.

W Xc

FIG. 4. Courtesy of Professor J. RUSKA and Staatsbibliothek, Berlin.

SUR L'HOMME

ET LE

DÉVELOPPEMENT DE SES FACULTÉS,

OU

ESSAI DE PHYSIQUE SOCIALE;

PAR A. QUETELET,

Secrétaire perpétuel de l'Académie royale de Bruxelles, Correspondant de l'Institut de France, de la Société royale astronomique de Londres, des Académies royales de Berlin, de Turin, etc.

Appliquons aux sciences politiques et morales la méthode fondée sur l'observation et sur le calcul, méthode qui nous a si bien servi dans les sciences naturelles.

LAPLACE, *Essai ph. sur les probabilités.*

TOME PREMIER.

PARIS,

BACHELIER, IMPRIMEUR-LIBRAIRE,

QUAI DES AUGUSTINS, N° 55.

1835

FIG. 5.
Harvard Library. Size, 21 × 13 cm.

LETTRES

à S. A. R.

LE DUC RÉGNANT DE SAXE-COBOURG ET GOTHA.

SUR LA

THÉORIE DES PROBABILITÉS,

APPLIQUÉE

AUX SCIENCES MORALES ET POLITIQUES:

PAR A. QUETELET.

BRUXELLES,

M. HAYEZ, IMPRIMEUR DE L'ACADÉMIE ROYALE DES SCIENCES, DES LETTRES ET DES BEAUX-ARTS DE BELGIQUE.

1846.

FIG. 6.

Harvard Library. Size, 26 × 17 cm.

Natural and *Political*

OBSERVATIONS

Mentioned in a following INDEX,

and made upon the 7 Ta

Bills of Mortality.

By JOHN GRAUNT,

Citizen of

LONDON.

With reference to the *Government*, *Religion*, *Trade*, *Growth*, *Ayre*, *Diseases*, and the several Changes of the said CITY.

—— *Non, me ut miretur Turba, laboro,*
Contentus paucis Lectoribus ——

LONDON,

Printed by *Tho: Roycroft*, for *John Martin*, *James Allestry*, and *Tho: Dicas*, at the Sign of the *Bell* in St. *Paul's* Church-yard, MDCLXII.

FIG. 7.

British Museum. Size, 17 × 13 cm. The word *Observations* is 10 cm. long (see appendix).

gradually decline till there be none left to *die*; as may be seen at one View in the Table.

From these Considerations I have formed the *adjoyned Table*, whose Uses are manifold, and give a more just *Idea* of the *State* and *Condition* of *Mankind*, than any thing yet extant that I know of. It exhibits the *Number* of *People* in the City of *Breslaw* of all Ages, from the *Birth* to extream *Old Age*, and thereby shews the Chances of *Mortality* at all *Ages*, and likewise how to make a certain Estimate of the value of *Annuities* for *Lives*, which hitherto has been only done by an imaginary *Valuation*: Also the *Chances* that there are that a *Person* of any *Age* proposed does live to any other *Age* given; with many more, as I shall hereafter shew. This *Table* does shew the *number* of *Persons* that are living in the *Age* current annexed thereto, as follows:

Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age.	Persons.
1	1000	8	680	15	628	22	583	29	539	36	481	7	5547
2	855	9	670	16	622	23	579	30	534	37	474	14	4584
3	798	10	661	17	616	24	574	31	529	38	468	21	4270
4	760	11	653	18	610	25	567	32	525	39	456	28	3964
5	732	12	646	19	604	26	560	33	507	40	445	35	3504
6	710	13	640	20	598	27	553	34	499	41	435	42	3198
7	690	14	634	21	592	28	546	35	490	42	427	56	2707
Age Curt.	Per-sons.	Age. Curt.	Per-sons	Age. Curt.	Per-sons	Age Curt.	Per-sons	Age. Curt.	Per-sons	Age. Curt.	Per-sons	63	1654
63	417	70	246	77	272	84	208	91	81	98	38	70	1204
64	407	71	393	78	262	85	194	92	120	99	28	77	693
65	397	72	384	79	252	86	188	93	109	80	18	84	253
66	387	73	373	80	242	87	172	94	98	81	8	100	107
67	377	74	362	81	232	88	162	95	87	82	28		34000
68	367	75	352	82	222	89	152	96	78	83	23		
69	357	76	282	83	212	90	142	97	68	84	20	Sum Total.	

Thus it appears, that the whole People of *Breslaw* does consist of 34000 *Souls*, being the Sum *Total* of the Persons of all Ages in the *Table*: The first use hereof is

FIG. 8.

From E. HALLEY's paper in *Philos. Trans.*, vol. 17, no. 196, 1693, showing the earliest mortality table (Harvard Library).

16

G. SARTON

CINQ ESSAYS
SUR
L'Arithmetique Politique.

I. *On Répond aux Objections tirées de la Ville de* Rey *en* Perſe, *& a celles de Mr.* Auzout *contre les deux premiers Eſſays, & l'on fait voir qu'il y a autant de monde a* Londres *qu'a* Paris, Rome *&* Rouen *pris enſemble.*
II. *Comparaiſon entre* Londres *&* Paris *en* 14 *choſes particulieres.*
III. *Preuves qu'il demeure dans les* 134 *paroiſſes de* Londres *marquées dans les billets de mortalité, environ* 696 *mille perſonnes.*
IV. *Combien l'on eſtime qu'il y a de monde a* Londres, Paris, Amſterdam, Veniſe, Rome, Dublin, Briſtol *&* Rouen *avec pluſieurs remarques ſur ce Sujet.*
V. *Touchant la* Hollande *& les autres VII* Provinces Unies.

Par le Chevalier *PETTT* de la Société Royale.

Invidiam Augendo ulcifcar.

A *LONDRE*,
Impremie pour *Henry Mortlack* au *Phœnix* dore dans le Cimetier de St. *Paul.* 1687.

FIVE ESSAYS
IN
political Arithmetick,
VIZ.

I. Objections from the City of *Rey* in *Perſia*, and from Monſ^r *Auzout*, againſt two former Eſſays, anſwered, and that *London* hath as many People as *Paris*, *Rome* and *Rouen* put together.
II. A Compariſon between *London* and *Paris* in 14 particulars.
III. Proofs that at *London*, within its 134 Pariſhes named in the Bills of Mortality, there live about 696 thouſand People.
IV An eſtimate of the People in *London*, *Paris*, *Amſterdam*, *Venice*, *Rome*, *Dublin*, *Briſtoll* and *Rouen*, with ſeveral obſervations upon the ſame.
V. Concerning *Holland* and the reſt of the VII *United Provinces*.

By Sir *WILLIAM PETTI*, Fellow of the Royal Society.

Invidiam augendo ulciſcar.

LONDON,
Printed for *Henry Mortlack* at the *Phœnix* in St. *Paul's* Church-yard. 1687.

FIG. 9.

British Museum. The top words "Five essays" measure 63 mm). This book is printed in French and English on opposite pages (twice 48 p.)

ENGLAND'S

GUIDE

TO

INDUSTRY:

OR,

Improvement of Trade, for the good of all People in general.

LONDON,

Printed by *R. Hols* for *T. Passinger* at the three *Bibles* on *London-Bridge*, and *B. Took* at the *Ship* in St. *Pauls-Church Yard*. 1683.

FIG. 10.

Surreptitious edition of *Political Arithmetick*, 1683. Bodleian Library (See Appendix).

Political Arithmetick,

OR

A DISCOURSE

Concerning,

The Extent and Value of Lands, People, Buildings; Husbandry, Manufacture, Commerce, Fishery, Artizans, Seamen, Soldiers; Publick Revenues, Interest, Taxes, Superlucration, Registries, Banks; Valuation of Men, Increasing of Seamen, of Militia's, Harbours, Situation, Shipping, Power at Sea, &c. As the same relates to every Country in general, but more particularly to the Territories of His Majesty of *Great Britain*, and his Neighbours of *Holland*, *Zealand*, and *France*.

By Sir *WILLIAM PETTY*,
Late Fellow of the *Royal Society*.

London, Printed for *Robert Clavel* at the *Peacock*, and *Hen. Mortlock* at the *Phœnix* in St. *Paul's* Church yard. 1690.

FIG. 11.

First authorized edition. British Museum. The top words *Political Arithmetick* measure 75 mm.

if the alternatives are COMTE or QUETELET,—surely it was not COMTE, but QUETELET.

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From 1834 on, QUETELET was perpetual secretary of the Belgian academy, a post which his encyclopaedic tendencies and his universal curiosity made highly suitable for him. He was able to stimulate not only the scientific activities of his countrymen in almost every direction, but also, though to a lesser extent, their literary and artistic efforts. He soon realized that one of the best means of originating or encouraging new endeavours was to tell the history of the earlier ones and this was probably what induced him to devote a part of his precious time to historical investigations.

There are a number of historical notes in the *Correspondance mathématique* (23), but his first historical paper outside of his own journal appeared in 1835 (the very birthyear of *Sur l'homme*), in the form of a report submitted at the Dublin meeting of the British Association for the Advancement of Science : " Aperçu sur l'état actuel des sciences mathématiques chez les Belges " (*Report of the fifth meeting B.A.A.S.*, 35-59, 1836). The purpose of this paper was not only to spur on his countrymen, but to show the world what the new Belgium (then barely five years old) had already accomplished. After 1835, his statistical investigations engrossed his thoughts so deeply that he had no time for historical writing, except a few obituaries, and a note on the ancient academy of Brussels, (24) until almost thirty years later.

In 1864 and 1866 he published two large volumes : *Histoire des sciences mathématiques et physiques chez les Belges* (480 p., Bruxelles, 1864) and *Sciences mathématiques et physiques chez les Belges au commencement du XIX*^{e} *siècle* (IV+754 p., Bruxelles, 1866).

The first of these volumes is a history of science in Belgium, with the general history of that country and the history of art,

(23) For example, the first volume (1825) contains notes (by himself) on HUYGENS' MSS., GREGORY ST. VINCENT, GEMMA FRISIUS.

(24) Sur les travaux de l'ancienne Académie (*Bulletin de l'Académie de Belgique*, vol. 5, 14 p., 1858).

as a background. It is divided into four books: I. From the beginning (Roman times) to the birth of CHARLES THE FIFTH in 1500 (56 p.), II. To the end of the governorship of ALBERT and ISABELLA, 1633 (118 p.), III. To the foundation of the Academy of Brussels, 1773 (93 p.), IV. To the independence of Belgium, 1830 (92 p.). This is followed by two irrelevant appendices, explaining the purpose and functions of the Royal Observatory of Brussels, and a project of a Belgian Pantheon to be established in the Park of that city. It is clear that QUETELET's historical efforts were largely inspired by his ardent love of the country whose rebirth in freedom it had been his privilege to witness. Moreover he was himself one of the leading artisans and promoters of the new kingdom, his own share in that leadership being especially glorious, as the scientific revival was largely due to him.

The second volume is, as the title suggests, a continuation of the first, but a very irregular one. It would perhaps be more correct to call it a collection of materials for the use of later historians. It is divided into four books: I. Organization of scientific research in Belgium, and international organization of science (a field of which QUETELET was one of the pioneers). II. Biographies of fourteen contemporary Belgian scientists. III. Biographies of Belgian men of letters and artists. IV. Biographies of twelve foreign scientists (25).

These two historical works of 1864 and 1866 are somewhat heavy and repetitious; the author's patriotism and his zeal to illustrate the scientific achievements of his people were greater than his historical experience. These books are not distinguished except as the historical contributions of a very distinguished scientist. However it may still be useful to refer to them, especially to the second which is partly in the nature of memoirs, and as such really valuable in spite of careless writing. They contain the reactions of a candid witness to many scientific personalities and to important events of his time, —*quorum pars magna fuit*.

QUETELET lacked historical training and had no conception of

(25) ARAGO, HUMBOLDT, ALEXIS BOUVARD, H. C. SCHUMACHER, GAUSS, GOETHE, GIOBERTI, F. X. J. DROZ, MALTHUS, A. R. FALCK, D. J. VAN EWIJCK, baron DE KEVEBERG DE KESSEL. These notices are interesting because they include personal recollections. With regard to QUETELET's contacts with GOETHE, see AUGUSTE COLLARD: GOETHE *et* QUETELET (*Isis* 20, 426-35, 1934).

historical difficulties. In this he was perhaps less excusable than other scientists because his long experience in another—his own chosen—field should have taught him that things are not always as simple as they look. History is just as easy, or as difficult, as statistics : it is just as easy to write poor history as to compile poor statistics; it is just as difficult to do good historical work as to do good statistical work. Keenly aware as he was of the many statistical pitfalls, he seemed unconscious of the historical ones, and as a result he made himself ridiculous in one remarkable instance. He published two letters purported to have been written by his " illustrious countryman " (26) the Holy Roman Emperor CHARLES V to FRANÇOIS RABELAIS in 1542. CHARLES wrote to Maistre RABELAIS (in French) that he had promised a thousand écus to whomever would solve the quadrature of the circle, but in vain. Would not RABELAIS try ? The archivist LOUIS PROSPER GACHARD proved that these two letters were apocryphal. Their text had been communicated to QUETELET by the French geometer and historian MICHEL CHASLES (1793-1880). It was not yet known then that poor CHASLES had been for years the chosen victim of a clever and unscrupulous forger, otherwise QUETELET's discomfiture would have been even worse (27).

Two other historical papers deserve mention. " Tables de mortalité et leur développement " (*Bulletin de la Commission centrale de statistique de Belgique*, tome 13, 40 p., Bruxelles, 1872). The first part of this paper (p. 4-17) is historical. It contains a very interesting comparison (tabular and otherwise) between nineteen mortality tables, beginning with HALLEY's famous Breslau table of 1693. The second paper was the " Premier siècle de

(26) CHARLES-QUINT was born in Ghent in 1500; he died in 1558. RABELAIS was born c. 1490 and died in 1553. The letters were published in the *Bulletin de l'Académie de Belgique* (vol. 22, 204-7, 1866). Controversy with GACHARD and facsimiles (*ibidem*, 343-6, 478-9, 544-5).

(27) See P. TANNERY's notice on CHASLES in the *Grande Encyclopédie* or in his *Mémoires* (vol. 6, 517-21). " Son goût pour les recherches historiques lui attira une mésaventure célèbre. Un faussaire, du nom de VRAIN-LUCAS, lui vendit successivement, par pièces détachées, une immense collection d'autographes dont CHASLES se servit notamment pour revendiquer en faveur de PASCAL un certain nombre de découvertes qui font la gloire de NEWTON. FAUGÈRE en France, BREWSTER en Angleterre, démontrèrent la fausseté des pièces invoquées par CHASLES et finalement celui-ci, en 1869, reconnut cette fausseté et fit poursuivre VRAIN-LUCAS qui lui avait extorqué près de 200.000 francs."

l'Académie royale de Belgique," which QUETELET contributed as its perpetual secretary to the memorial volumes celebrating its first centenary, *Académie royale de Belgique. Centième anniversaire de fondation*, 1772-1872 (2 vols., Bruxelles, 1872). QUETELET's paper covers p. 117 to 174 of the first volume. He was admirably qualified for the writing of this general survey, for he had been the academy's moving spirit for almost forty years, that is, for a substantial part of its whole existence, the period of maximal activity up to that time.

We gather from the preface to his book of 1866 that he was planning to write in cooperation with his son, the astronomer ERNEST ADOLPHE FRANÇOIS QUETELET (1825-1878) three more volumes on the history of science in Belgium, dealing respectively with astronomy, meteorology, and terrestrial physics, but on account of the father's death and the son's inefficiency, that project failed to materialize.

QUETELET's historical studies suggest another comparison with COMTE. The latter was one of the pioneers of the history of science movement (28), but as usual he preached by precept rather than by example. On the contrary, QUETELET's interest was concrete, and its application immediate. He undertook to write the history of science in his own country, and accumulated a considerable amount of materials for later historians. Unfortunately if he was a born statistician he remained until the end an indifferent historian.

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I like to think of the constant presence in any sound Republic of two guardian angels : the Statistician and the Historian of Science. The former keeps his finger on the pulse of Humanity, and gives the necessary warning when things are not as they should be. The Historian of Science—or let us say simply the Historian (for in the future every historian will have enough scientific training to appreciate the importance of science) will not allow Humanity to forget its noblest traditions or to be ungrateful to its greatest benefactors. If the Statistician is like a physician,

(28) G. SARTON : L'histoire de la science (*Isis* 1, 9, 1912).

the Historian is like a priest,—the guardian of man's most precious heritage, of the one treasure which, whatever may happen, can never be taken away from him—for the past is irrevocable. Humanity must be protected by the watchful Statistician, and it must be sustained in its newer and bolder efforts by the consciousness of every antecedent effort, to which it owes its culture, its dignity and its excellence.

QUETELET realized these two needs ahead of the great mass of the people, even of the best educated, and such prophetic vision of the intellectual necessities of the future, if that is not genius, what else is it and what else is genius?

Cambridge, Massachusetts. GEORGE SARTON.

APPENDIX

Notes on the illustrations

Plate 1, fig. 1. We owe this portrait of QUETELET to the courtesy of his grandson, Mr. G. QUETELET, lawyer, and of Mr. AUGUSTE COLLARD, Librarian of the Royal Observatory in Uccle. According to G. QUETELET, this charcoal drawing is the portrait nearest to the date 1835.

Plate 2, figs. 2 and 3. As explained in the text, the *Physique sociale* of 1869 was not essentially different from the first edition published in 1835 under the title *Sur l'homme*. Thanks to the courtesy of the Department of applied statistics of University College, London, and of Mr. EGON SHARPE PEARSON, we are able to reproduce the title pages of the copy presented to FLORENCE NIGHTINGALE, bearing QUETELET's dedication in his own hand and Miss NIGHTINGALE's remarks in her own hand. As these inscriptions may be partly lost in the reproduction (the ends of some words have already been cut off in the binding), I give the full text here.

QUETELET's dedication: "*Mademoiselle Florence Nightingale. Hommage de respect et d'affection. L'auteur. Quetelet.*"

F.N.'s remarks on the half-title page: "*Organic periods = positive creed.*

Critical periods = no convictions but that the old ones are false.

Xtianity = *organic period.*
Reformation = *critical* »

Will last until a new organic period has been inaugurated by the triumph of a yet more advanced creed (? the New Moral World resulting from Law).

On the main title page :

the sense of infinite power
the assurances of solid certainty
the endless vista of improvement

from the principles of PHYSIQUE SOCIALE if only found possible to apply on occasions when it is so much wanted. Nov. 1, 70 [the date being cut by the binder is uncertain; it might be read Nov. 17 without indication of year].

These remarks together with the passage which I quoted above from PEARSON's biography of GALTON, are highly significant and throw a new light on her personality.

Fig. 7. JOHN GRAUNT's *Natural and political observations* are said to have first appeared in 1661 but the earliest edition known is this one, 1662, which has the appearance of a first edition. It is possible that WILLIAM PETTY collaborated on the first edition; it is certain that he was the editor of the fifth—posthumous and improved—edition of 1676.

Fig. 10. According to DNB (45, 117), the *Political Arithmetick* written by PETTY as early as 1676 or 1677, was refused a license as likely to give offence in France. However, it was published surreptitiously and anonymously in 1683 under the title *England's guide to industry*, in the form of an appendix to another work. This photograph was made in the Bodleian Library from the unique perfect copy.

Natur- und Medizingeschichtliches aus dem Mahābhārata

Neben epischen und anderen Anteilen enthält das grosse Sammelwerk, *Mahābhārata*, auch lebens- und weltanschauliche Erörterungen philosophischen Einschlages, hauptsächlich bei den Ausführungen, im *Mokṣadharma* seines XII. *parvan*, aber auch in einigen anderen, weniger umfangreichen und verstreuten Abschnitten. Derartige philosophische Texte dürften gegen die Mitte des ersten nachchristlichen Jahrtausend Aufnahme gefunden haben in das *MBh* (= *Mahābhārata*), welches im folgenden nach seiner bekannten Ausgabe Calcutta 1834-9 ohne weiteres Kennzeichen zitiert wird (in Übereinstimmung mit der bekannten Übersetzung von DEUSSEN-STRAUSS). Diese Philosopheme dienten zum Ausbau ärztlicher Lehren, vor allem in der *CaS* (= *Caraka-Saṃhitā*, Editio Lahore 1929), und hier besonders in dem gösseren Teil des Abschnittes über den Körper (*śārīrasthāna*), welcher deswegen im 14. Jahrhundert von dem Jainamönch *Guṇaratna* anscheinend als ein besonderes philosophisches Fachwerk (*Ātreyatantra*) angesehen wurde. Im Journ. Roy. Asiat. Soc., 1932, *789-814* ist das Alter der frühesten grossen Zusammenfassung indischer Fachmedizin, der alten *Saṃhitas*, bei grober Schätzung nach der Mitte des ersten Jahrtausend angesetzt worden, unabhängig von dem Bezug der *MBh*-Anteile zur *CaS*. Die somit übereinstimmende zeitliche und inhaltliche Abhängigkeit der *CaS* von dem *MBh* gemäss dem zuvor umrissenen Rahmen lenkt eine medizinische Anteilnahme auf die betreffenden Abschnitte des *MBh*, zumal — schon seit vedischen Vorzeiten — die Erlösung (*mokṣa*) sich auf körperliche wie seelische Leiden erstreckte. Aus seinen vielgestaltigen und umfangreichen Texten sollen nachfolgend einige Momente untersucht werden, in einzelnen Beispielen und Belegen, ohne jedoch — wie ausdrücklich

betont — das Material im *MBh* zu erschöpfen noch jede, zuweilen angedeutete, ärztliche Theorie.

Die oben erwähnte Datierung vor 500 n. Chr. für die *MBh*-Teile und nach 500 hinsichtlich der *CaS* bezieht sich nur auf das Erscheinen der Texte im geschichtlichen Gesichtswinkel oder auf ihre früheste [mutmassliche] Redaktion. Das Alter von Einzelheiten des Inhaltes ist damit keineswegs bestimmt worden und noch weniger dasjenige des Entstehungsvorganges. Letzter reicht mitunter in die frühesten erkennbaren Zeitabschnitte zurück, soweit sich aus den *MBh*-Texten ein Rückblick gewinnen lässt. Einzel-Parallelen aus anderen, auch verwandten Überlieferungen — wie etwa aus der älteren *Upaniṣad*-Literatur — bieten hierbei meist unzulängliche Sicherungen in Prioritäts-Fragen. Mehr Erfolg für eine Kritik der Entwicklung verspricht die Berücksichtigung einer indischen Eigenart, nämlich der Vorliebe für Systematik, auf welcher sich auch in diesem Zusammenhang ein gut Teil der wissenschaftlichen Medizin aufbaut. Und diese Bemühung um Einordnung von Erfahrungen und deren Verwertungen ist auch oft genug im *MBh* erkennbar, z.B. in V, *1681* bei der Betonung der Unterscheidung (*vyākaraṇa*) aller Dinge im Sinne systematischer Sonderung, wie sie in den Abschluss der Erörterung über die Veden [in der hier allgemeinen Bedeutung des Wissens] eingefügt ist.

Auf einem allgemeinen, naturkundlichen Untergrund unterscheidet das *MBh* Pflanzen und Tiere durchweg als stehende (*sthāvara*) und gehende (*jaṅgama*); auch deren gebräuchliche Übersetzung durch unbewegliche und bewegliche wird inhaltlich der althergebrachten herrschenden Wertung nach der Funktion gerecht, welche sich bereits im *Ṛgveda* nachweisen lässt. Diese übliche Einteilung wird XII, *8700* erweitert bei den Tieren in zwei- und vierfüssige, offensichtlich in Anklang an die vedischen Zwei- und Vierfüssler, die in I, *3619* durch Sechsfüssler ergänzt werden. Die letzte Dreier-Systematik erscheint umfassender als jene nach laufenden, schwimmenden und kriechenden Tieren, wie sie in den *Yajus*-Überlieferungen auftaucht. XII, *8701 ff.* zerlegt dann die Gruppen der Zweifüssler bis zu den Menschen, welche nach brahmanistischen Prinzipien klassifiziert werden. Mindenstens dieser Ausklang muss als nachträglich zugefügt angesehen werden. Denn die grundsätzliche Gliederung ist

zuvor in *8698* dargelegt: A. aus Eihaut entstandene *(jarāyuja)*, B. aus Eischale entstandene (*aṇḍaja*), C. aus Spaltung oder Sprossung entstandene (*udbhijja*), D. aus Schwitzung entstandene (*svedaja*). Und dass hierbei die gültige Systematik vorliegt, beweist die oftmalige Wiederholung, wie in XII, *7005* (A. B. D. C.), *7689* (ohne Einzelnennung), *10282* (A. B. D. C.), *10396* (A. B. D. C.), *11594* (A. B. D. C.), XIV, *1134* (B. C. D. A.). In letztem Beleg werden auch einige Beispiele angefügt, zu B: Vögel (*khecara* = unter dem Himmel sich bewegend) und Kriechende (*sarīsṛpa*), zu D: Würmer (*kṛmi*), niedriger eingeschätzt als Wesen in C, welche die Erde spalten (*bhid*). Diese Systematik ist auch in den alten *Upaniṣad*-Überlieferungen nachweisbar: *Aitareya-* III, *3* (B. A. D. C.) und *Chāndogya-* VI, 3,*1* (B. A. C.). *CaS śārīra* 3,*23* dürfte jene Einteilung übernommen haben, wie der dortige allgemeine Bezug zum *MBh* nahelegt; aus dritter Hand stammt der Einschub im Beginn des *Mānava-Dharmaśāstra* (I, *43-45*) und der *SuS* (= *Suśruta-Saṃhitā*, Editio Bombay, 1931), wie in der WINTERNITZ-Festschrift *73-8* dargelegt ist. Diese Tierordnung, welche im indischen Rahmen fremdartig anmutet, erregte nicht nur Teilnahme bei den späteren Philosophen sondern auch ärzlichen Kommentatoren, wie z.B. bei *Candraṭa*, welcher nach JOLLY (Zschr. Deutsch. Morgenld. G., 1906, *413-469*) zwischen dem 11. und 14. Jahrhundert gelebt hat. In seinem Kommentar (zu *16*) sind die Tierarten mit den sogenannten 5 Elementen verbunden unter Verweis auf *Kharanāda*. Dieser Autor taucht wiederholt mit einem Ansehen wie *Caraka* oder *Suśruta* auf, wird im Kolophon unmittelbar nach *Bheṭa* genannt, dürfte jedoch kein hohes Alter beanspruchen nach anderen Belegen, welche von G. MUKHOPĀDHYĀYA in seiner History of Indian Medicine *763-770* gesammelt sind.

Wenn in den vedischen Zeiten der Mensch mit den Zwei- und Vierfüsslern vereinigt erscheint, so ist er — wenn nicht schon früher — nach philosophischen Tendenzen im *MBh* deutlich abgesondert, obwohl mitunter Atavismen erkennbar sind. Empirische Betrachtungen seiner körperlichen Systematik beginnen mit seinem embryonalen Zustand, wie solche sich auch in der Verbindung der Anatomie mit der Entwicklungsgeschichte durch die Fachmedizin widerspiegeln. Unter Betonung gegenüber anderen Theorieen weist XII, *11329* darauf hin, dass der Keim

(*garbha*) ohne Mann (*puruṣa*) und Weib (*strī*) nicht entstehen kann. Wie nach medizinischen Lehren, so auch nach XIV, *501* gelangt der Samen des Mannes und das Blut der Frau in die Keimlagerung (*garbhāśaya*); der letzte Fachausdruck entspricht einer funktionellen, nicht einer anatomischen Auffassung, denn der uterus des Menschen ist in den alten Zeiten nicht nachweisbar bekannt. Deshalb betont auch XII, *9111* (vgl. auch *12535-7*), dass der Keim in der Bauchhöhle (*kukṣi*) nicht wie Speise verdaut wird (*jar*). Der Samen (*śukra* = leuchtend) kommt hier in die Hitze (*uṣman*, mutmasslich = Menstrualblut) und ist nach XII, *6982* selbst eine Feuerform (*tejomaya*), gemäss den altarischen Vorstellungen, welche bei dem Begriff des Feuers bereits Wärme und Licht systematisch vereinen. Ein Überblick der embryonalen Entwicklung wird in XII, *11967-9* gegeben: aus Samen und Blut entsteht ein Knöllchen (*kalala*), welches sich zur kleinen Blase (*budhuda*) und darauf zu einem Fleischklumpen ausbildet, dem dann Glieder, Nägel und Haare entwachsen. Diese Beschreibung wird einer Frau, *Sulabhā*, in den Mund gelegt. Der Vorgang kennzeichnet das Interesse breiter Kreise, wie auch in *Garbha-Upaniṣad* 3 ersichtlich. Die ältesten Beobachtungen entstammten zweifellos dem Tieropfer; sie wurden daraus von Ärzten übernommen und in ihren Fachüberlieferungen weitergetragen, waren wohl auch mittel- oder unmittelbar auslösend für das *MBh*. Auf einen Einfluss durch Ärzte, welche bekanntlich die Jahreszeiten besonders einteilten, kann auch die Berechnung der Schwangerschaft nach 9 Monaten in *11969* zurückgeführt werden gegenüber der sonst üblichen und volkstümlichen Dauer von 10 (Mond-) Monaten, die in *9111* und *12529* erwähnt wird (vgl. einige Beispiele im Archiv f. Geschichte d. Med. 1928, *237*).

Bei der Zusammensetzung des menschlichen Körpers wird in XII, *11348* Haut, Fleisch, Blut, Fett, Galle, Mark und Sehnen aufgezählt, in Anklang an die bekannte Stelle in *Śatapathabrāhmaṇa* X, 4, 1, *17*. In letztem ist aber die allgemein gültige Einteilung: Haar (*loma* = Körperhaar, sc. des Opfertieres), Haut, Fleisch, Knochen Mark, welche sich aus den Opfertexten des weissen und scharzen *Yajus* entwickelt hatte. Dagegen scheint XII, *11352* (Haut, Fleisch, Fett, Galle, Mark, Knochen, Sehnen und Samen) mehr die ärztliche *Dhātu*-Lehre zu berücksichtigen

(vgl. Sudhoffs Archiv, 1933). Denn diese Auffassung als Metamorphose ist in XIV, *570-1* angedeutet: die Speise geht dort in den Körpersaft über, dieser in das Blut, welchem dann für eine Weiterentwicklung (des Embryo) Fleisch, Fett, Sehnen, Knochen angereicht werden; in *573* werden auch Abbaustoffe durch *mala* bezeichnet, wie bei Ärzten üblich. Nach XII, *11332-3* stammen Knochen, Sehnen und Mark vom Vater ab, Haut, Fleisch und Blut von der Mutter. Gefässe (*sirā*) und Sehnen (*snāyu*), welche auch in der Fachmedizin häufig zusammen genannt werden, sowie Knochen können in XII, *10913-4* als eine Art funktionell-statisches Moment beurteilt werden, im Vergleich mit dem Überzug durch die Haut. Ein solcher Bezug gründet sich auf Vorstellungen von einem Wohnraum, wie zuvor in *10911* erwähnt. Auch XII, *12463* schildert einen solchen, anscheinend zeltartigen Raum, dem die Knochen als Stützen (*sthūṇa*), die Sehnen zum Anspannen (*yu*), das Fleisch und Blut zum Beschmieren (*lip*) und die Haut zum Überziehen oder Überdecken (*avanah*) dienen. Derartige Betrachtungen des Menschenkörpers sind beliebt, wie VI, *1048*, XII, *6517*, *7679*, *8765*, *9124-30*, *9658* zeigt. Der Insasse dieses Raumes bzw. Leibes ist das innere Selbst (*antarātman*), der *puruṣa*, der „Mann" in engerer Bedeutung. Er wird nicht gesehen, weil er sich im Herz niedergelassen hat; seine Grösse wird nach V, *1764* und *1786* als Daumenbreite (*aṅguṣṭha*) angegeben, worauf sich XII, *11026* und anscheinend das Mass von 2 oder 3 *aṅgulas* in *CaS vimāna* 8, *14*, *7/14* bezieht. Dieselben Vorstellungen bestehen in *Kaṭhaka-Upaniṣad* IV, 12-13, *Śvetāśvatara-Up.* III, 13 und *Mahānārāyaṇa-Up.* XVI, 3. Danach kann das Mass *prādeśa* im Herz („*hṛdi*") in XII, *8942* nur auf den Daumen bezogen werden, zumal kurz darauf, *8946*, von der Höhle des Herzens gesprochen wird. In XII, *6842* ist der Begriff vom Herz (*hṛdaya*) sogar zu dem der Brusthöhle erweitert unter Gegenüberstellung zur Bauchhöhle (*koṣṭha*), wie das auch in der Fachmedizin nachweisbar ist. Derartig anatomisch-topographische Vorstellungen sind beim Herz nicht die ausschlaggebenden. Bereits aus der arischen Frühzeit liefen hier Lebensanschauungen ein (vgl. „Die Medizin im Ṛg-Veda, Asia Major, 1930, *387*"), welche sich kritisch als Beachtung von Affekten einengen lassen (etwa im Gegensatz zum Denken) und in der Fachmedizin mit der Sinnesphysiologie verbunden werden (vgl.

„On the hearth in acient Indian medicine", Journ. of Ayurveda, 1934). Der Stamm der Entwicklung dieser komplizierten Vorstellung weist jedoch in Richtung eines Seelen-Begriffes. Eine solche Bahn wird beispielsweise in der *Bṛhadāraṇyaka-Upaniṣad* IV, 3, 7 betreten bei der Frage nach dem Selbst (*ātman*) mit dem Ergebnis, dass der *puruṣa*, ein Licht (*jyotis*) im Herz, aus Erkenntnis gebildet (*vijñānamaya*) ist. Dieser *puruṣa* wird wiederholt im *MBh* als *kṣetrajña* bezeichnet, d.h. als Kenner (*jña*) des *kṣetra* (Ort, Wohnung etc.), welch letzte z.B. in VI, *1325* ausdrücklich als der Leib (*śarīra*) erklärt wird. Derartige Doktrinen sind im *MBh* vielseitig ausgebildet; sie können in ihrem philosophisch-psychologischen Einschlag hier und später nur kurz gestreift werden, soweit sich engere Berührungsflächen zum Thema bieten. Bei ihrer Verbindung mit den Tendenzen einer Erlösung von Leiden entstand auch eine abfällige Beurteilung der Körperanteile des Menschen. In XII, *12463* könnte jene Abwertung durch den Ausdruck *lip* (schmieren) angedeutet sein; sie wird jedenfalls unterstrichen durch die vorgebrachten Eigenschaften des Missriechens (*durgandhi*) und durch die Anreihung von Harn und Kot, wie ähnlich in XII, *10913* und anderen möglichen Belegen.

Aus dieser absprechenden Wertung fallen allgemein die fünf *mahābhūtas* heraus. Ihre gebräuchliche Übersetzung durch „Elemente" („Feuer, Wasser, Erde, Luft, Äther") mag mitunter einer praktischen Bequemlichkeit nicht entbehren. Aber selbst wenn dabei ein moderner elementarer Begriff ausgeschaltet würde oder ein genetischer Zusammenhang mit den Lehren des EMPEDOKLES, PLATO oder ARISTOTELES (vgl. BÖTHLINGK, Verhandlg. Kgl. Sächs. Ges. d. Wiss. Leipzig, 1899, *149-151*), so würde eine solche begriffliche Übertragung den bodenständigen Vorstellungen von den *mbh* (= *mahābhūtas*) nicht gerecht werden.

Das System der *mbh* erscheint bevorzugt im *MBh* als eine Grundlage der Physiologie und ihrer Erweiterungen. Seine geschlossene Festigkeit beweist mit einigen Varianten, dass es nicht erst kurz vor dem redaktionellen Abschluss entstanden sein kann. Seine Prinzipien lassen sich bereits in den älteren *Upaniṣad*-Überlieferungen nachweisen, deren Lehren die Naturvorgänge und Naturkräfte erkenntnistheoretisch aus ihren Vorstellungen von Göttern als Personen lösten (vgl. HERTEL,

Indogerman. Forschgn., 1923, *188*). Als Atavismus kann es daher beurteilt werden, wenn z.B. in XII, *11561* die *mbh* männliches und nicht (wie gewöhnlich) sächliches Geschlecht besitzen. Nach JACOB (Concordance, *732*) kommt der Ausdruck *mbh* selbst nur in jüngeren Texten der *Upaniṣad*-Überlieferung vor: in *Prāṇāgnihotra*- 4; *Aitarsya*- III, 3 und *Maitrāyaṇa*- III, 2 liesse sich noch zufügen. Dort oder anderwärts ist jedoch keine Begründung erkennbar, warum die *mbh* ein beherrschendes Moment der Physiologie im *MBh* bilden. Ob ein ärztlicher Einfluss hierbei angenommen werden darf, lässt sich bei den unzureichenden Kenntnissen aus der Frühzeit nicht sichern. Somit bleibt nur die allgemeine und althergebrachte Grundlage des Bezuges zwischen Makro- und Mikrokosmos übrig.

Ein Auszug von hauptsächlichen Bezeichnungen für die einzelnen *mbh* aus den *MBh*-Texten bietet zwar ein buntes Bild, aber keine wesentlichen Unterscheidungen der Bedeutungen im Rahmen des vorliegenden Themas.

1. Raum = *antarikṣa*, *ākāśa*, *kha*, *nabhas*, *vyoman*.
2. Wind = *anila*, *marut*, *vāta*, *vāyu*, (*prāṇa*, eigentlich: Atem).
3. Feuer = *agni*, *anala*, *uṣman*, *jyotis*, *tejas*, *div*, *pākava*, *vahni*.
4. Wasser = *ap*, *ambhas*, *udaka*, *jala*, *toya*, *vāri*, *salila*.
5. Erde = *urvī*, *jagatī*, *devī*, *dharā*, *pārthiva*, *pṛthivī*, *bhū*, *mahī*, *vasudha*.

Die Übersetzung „Raum" entspricht nicht ganz der jeweiligen Bedeutung des 1.*mbh*. Räumliche Vorstellungen sind zweifellos ursprünglich mit den Ausdrücken verbunden worden, wie z.B. bei *kha* = Höhle, und auch der Sachlage nach in den *MBh*-Texten erkennbar. Aber bereits die erstgenannte Bezeichnung, *antarikṣa*, regelmässig in der *Yajus*-Überlieferung gebraucht, wird in *Śatapathabrāhmaṇa* VII, 1, *2*, *23* mit *īkṣa* (von *īks* = strahlen, sehen) erklärt und durch *antarenākāśa* (die Zustrahlung durch den Zwischenraum). Bei *ākāśa* (Herbei-Strahlung), eine Bezeichnung, welche sich auch in der ärztlichen Physiologie erhalten hat, tritt noch mehr eine Doktrin in den Vordergrund, welche sich auf der alten, arischen Feuerlehre aufbaut. Zu ihrem Verständnis bedarf es des nachdrücklichen Hinweises auf die grundlegenden Untersuchungen durch HERTEL in den Indo-Iranischen Quellen und Forschungen und in den Abhandlungen d. phil.-hist. Kl. d. Sächs. Akad. d. Wiss., 1929 u. 1931.

Wenn auch die Anordnung der *mbh* nicht selten in den vielen Belegen verändert ist, so stellt die oben gegebene Reihenfolge doch die richtige oder theoretisch begründete Fçlge dar. Denn diese baut sich auf der Lehre der Entwicklung der *mbh* auf. XII, *8514-7* erörtert : aus dem Raum, indem er sich umgestaltet (*vikar*), wird der Wind erzeugt *(jan)*, ebenso aus dem Wind das Feuer, aus dem Feuer das Wasser, aus dem Wasser die Erde. Diese grundsätzliche Lehre wird oft wiederholt, wie in XII, *6778-9*, *6812-20*, *7394-5*, *7669-70*, *8514-6*, *8977*. In umgekehrter Reihenfolge löst sich auf oder schwindet (*pra-lī*) gemäss XII, *12893-4* die Erde in Wasser, das Wasser in Feuer, das Feuer in Wind, der Wind im Raum. Auch diese rückläufige Umwandlung wird oft wiederholt, wie in XII, *8977*, *11505-600*, *12893-4*, *13376-80*, *13462-3*. Der Auf- und Abbau wird auch hintereinander aufgezählt, z.B. in XII, *7394-5*, wobei der regressive Lauf durch die Tendenz der Erlösung (*mokṣa*) mitbedingt erscheint (vgl. *10910*, *10915*). Aber auch dabei bleibt das Gesetz bestehen : somit schwindet jedes *mbh* in demjenigen, aus welchem es erzeugt worden ist; die *mbh* schwinden in der umgekehrten Reihenfolge, als sie auseinander erzeugt worden sind (XIV, *1105*). Dieses physiologische System enstammt — wie oben angedeutet — den Anschauungen vom Makrokosmos. Der Bezug zum Mikrokosmos wird z.B. in XII, *6821* gestreift, nachdem zuvor die Erscheinungen in der Grosswelt erläutert worden sind. Wenn schliesslich die Anordnung der Belege — wie oben aus sachlichen Gründen aufgesucht — überblickt wird, so könnte eine schrittweise Entwicklung der Theorie von den *mbh* abgeleitet werden, etwa im Einklang mit der Annahme von aufeinander folgenden Zeitschichten des Niederschlages der Lehren einzelner Schulen; doch muss für solche Gesichtspunkte eine Unzuverlässigkeit eingeräumt werden.

Im Beginn des Gesamtwerkes des *MBh*, bei der Schilderung der Entstehung der Welt, werden bereits die *mbh* erwähnt. Hier (I, *36*) wird das Feuer als *div* bezeichnet; diese auffällige Benennung des Feuers in der Reihe „*apodyauḥ pṛthivī vāyurantarīkṣam*" beweist einmal, dass unter *div* hier nur das Himmelsfeuer oder der Feuerhimmel der arischen Weltanschauung gemeint sein kann, anderseits, dass bei dem Mangel jeder erklärenden Erweiterung ein allgemeines Verständnis für diesen Ausdruck

im *MBh* vorausgesetzt werden muss. Im Anschluss daran erhebt sich für eine kritische Untersuchung die Frage, ob die Systemreihe der *mbh* nur auf sinnfälligen Erfahrungen oder Beobachtungen ruhte, oder ob sie mit einer theoretischen oder wissenschaftlichen Einstellung verbunden ist, welche in der Feuerlehre angebahnt wurde. Eine zusammenfassende Antwort auf diese Frage, welche durch moderne geschichtswissenschaftliche Untersuchung ausgelöst wurde, kann von vornherein kaum aus den alten Texten erwartet werden. Die Brahmanen erörterten grundsätzliche Einstellungen nicht häufig, scheinen sogar mitunter solche Erklärungen zu vermeiden. Ähnliche Verhältnisse lassen sich auch in der Fachmedizin beobachten; es sei hier nur an den Mangel für eine kritische Übersicht der Entwicklung der *Doṣa*-Lehre erinnert, der sogenannten Humoral-Pathologie (vgl. *Janus* 1934). Jener Ausfall lässt sich mannigfach begründen, z.B. durch die eigenartige geschichtliche Einstellung der Inder. Wenn Grundsätze nicht bekannt waren, mag wohl auch mündliche Erläuterung eingeschaltet worden sein, welche aus der Frühzeit selten in den Texten bewahrt wurde. Manches war dabei überhaupt nicht für die Öffentlichkeit oder jedermanns Verständnis bestimmt; die Erklärung der Bezeichnung *Upaniṣad* als „Geheimlehre" weist in eine derartige Richtung. Daher treten auch im *MBh* Anhaltspunkte für die ursprüngliche theoretische Bedeutung der *mbh* nur gelegentlich und verstreut in Erscheinung. Sie lassen sich aber unschwer in einigen Beispielen zusammenstellen, nachdem einmal durch HERTEL eine Richtlinie dargelegt worden ist.

In XII, *9879* werden die 5 *mbh*, welche dann namentlich aufgezählt werden, als grosse Feuer (*tejas*) bezeichnet, oder in *13038* als aus Feuer bestehend (*tejomaya*) erklärt. XIV, *1112* nennt sie gleichfalls Feuer (*agni*). XIV, *1177* lehrt, dass der Herr der *mbh* stets das Feuer ist, der Herr des Feuers der Brahmanen („*agnirbhūtapatirnityaṃ brāhmāṇāṃ bṛhaspatiḥ*"). In Übereinstimmung mit den vedischen Lehren setzt betonend das *MBh* das Feuer allen Göttern gleich (XIV, *720* : „*agnirvai devatāḥ sarvā*"). Gemäss der alten *Upaniṣad*-Lehre erwähnt das *MBh*, dass das Feuer auch *brahman* ist (XII, *13196* : „*sa cāgnirbrahman*"); ebenso ist in XII, *7320* der Gott *Brahman* mit dem Feuer ausgeglichen. Auch der *Upaniṣad*-Bezug von *brahman* zum *ātman* wird in XII, *9044* gestreift, wobei das Selbst, *ātman*, als rauchlose

Flamme erläutert wird. Für manche derartige Bezeichnungen, welche wörtlich Feuer bedeuten, — wie z.B. *tejas* — könnten Fachausdrücke angenommen werden, in begrifflicher Weiterentwicklung und aus einem philosophischen Gesichtswinkel betrachtet. Die mannigfache Sachlage in den verschiedenen Belegen zeigen aber denselben Leitgedanken bei den Vorstellungen und daher, dass eine Feuer-Anschauung überall zum wenigsten mitschwingt. Die grundsätzliche Theorie wird aber dadurch nicht verwischt. Gemäss XII, *6781* stammen von dem Grossfeuer *Brahman* die 5 *mbh* ab (welche hier *dhātu*s genannt werden, wie weiter unten erklärt). Und die Erörterung über die Wissenschaft der Brahmanen, welche auch die *mbh* entwickelt, wird in III, *13913* eingeleitet: es gibt nichts höheres als [die Lehre], dass *brahman* die *mbh* verkörpert („*mahābhātātmakaṃ brahma nātaḥ parataraṃ bhavet*"), eine Doktrin, welche in den weiteren Texten in irgend einer Weise öfter wiederholt wird — wie z.B. in XII, *13371* bei der Herkunft von [dem Gott] im Schoss des Lotos (*padmayoni*), welcher selbst aus Feuer besteht (*6779*). Der letzte Beleg zeigt auch, wie verflochten die Grundanschauungen sich gestalteten, auf welchen sich in den *MBh*-Texten die erkenntnistheoretische Wertung der *mbh* als Feuer aufbaute.

In XII, *6775* beginnt eine Belehrung des *Bharadvāja* seitens *Bhṛgu* über die Entstehung der Welt und ihre Einteilung, wobei wiederholt die Entwicklungsreihe der *mbh* eingefügt ist. Bei der Zusammenfassung in 6821 taucht hier eine andere Bezeichnung für die *mbh* auf: Diese sind die fünf *dhātu*s, welche ursprünglich *Brahman* erzeugt hat, von welchen die Welten umgewandelt werden, und welche als *mbh* bezeichnet werden („*ya ete dhātavaḥ pañca brahmā yānasṛjat purā | āvṛtā yairime lokā mahābhūtābhisaṃjñataḥ*"). Hier entspricht also *dhātu* den *mbh*, wie das auch die alten einheimischen Wörterbücher erklären, sowie die *MBh*-Texte inhaltlich bestätigen — vgl. z.B. XII, *6780-1*, *7936*, XIV, *991*. Jedoch erläutert III, *13930*: Überall werden die Dinge, welche sich auf die fünf *mbh* beziehen als *dhātu*s betrachtet („*tatra tatra hi dṛśyante dhātavaḥ pañcabhautikāḥ*"). Diese Bemerkung legt nahe, dass ein Unterschied zwischen den Bezeichnungen *mbh* und *dhātu* angenommen werden muss. Eine generelle Differenzierung ist erschwert, weil der Ausdruck *dhātu*

sachlich auf sehr verschiedenen Gebieten verwandt wird. Sprachlich ist *mbh* eine Partizipialform von *bhū* = werden, entstehen etc., drückt also den Abschluss einer Tätigkeit aus: das Gewordene, ein stofflich Gebildetes. In diesem Sinne ist z.B. XII, *12897* zu verstehen, dass die fünf *mbh* als Gross-Körper (*ātman*) zu dem zusammengekommen sind, der als Leib (*śarīra*) bezeichnet wird. Dagegen ist *dhātu* ein substantivierter Infinitiv von *dhā* = legen, setzen — bereits in alten Texten — in einen Zustand versetzen; die gebräuchliche Übersetzung durch „Lage" müsste daher den Begriff einer Handlung umgreifen. Nur darf mit dieser Definition durch eine Tätigkeit nicht ein abstrakter Begriff den altindischen Vorstellungen aufgezwungen werden. *Dhātu* ist genau so konkret oder stofflich zu werten, wie die *mbh* nach den bodenständigen Anschauungen, wie später kurz gestreift. Die Unterscheidung von *dhātu* und *mbh* beruht demnach auf dem einer Funktion und ihres Ergebnisses. Erste lässt sich vielleicht schon im *Rgveda* in den 28 Verbindungen von *dhātu* mit der Zahl 3 bzw. 7 erblicken. Deutlicher ist *Chāndogya-Upaniṣad* VI, 5, *1* (vgl. *Maitrayāṇa-Up.* II, 6), wo sich die Nahrung dreifach teilt: ihr gröbster *dhātu* wird zu Kot, ihr mittlerer zu Fleisch und ihr feinster zu *manas* (Denkstoff). Die inhaltliche Bedeutung von *dhātu* weist hier also auf eine Umwandlung, welche durch parallel gebrauchte Wortwendungen eines Bezuges zur Umwandlung (*vaikarika*) und einer Ausstrahlung oder Entwicklung (*sarga*) in XIV, *1089* erläutert erscheint. Die Fachmedizin führt diese begriffliche Anschauung weiter aus (vgl. „Zur Lehre vom Stoffwechsel in der altindischen Medizin", Fortschritte der Medizin, 1933, *1009 ff.*).

Der zuvor herangezogene Lehrabschnit erläutert XII, *6823* die Bezeichnung *mbh*: Dabei bezieht sich (*upapad*) das Wort Gross (*mahāśabda*) auf den Fachausdruck *mbh* zum Unterschied von anderen *bhūta*s, d.h. Wesen, worunter Dämonen (so auch in der Fachmedizin) oder hier Menschen zu verstehen sind. Die letzte Bezeichnung, *bhūta*, war also die allgemein bekannte, welche durch das Vorwort *mahat* erst einen besonderen Sinn in den Lehren des *MBh* erhielt. Und in diesem Sinn ist die — auch sonst häufige — Kurzform *bhūta* als *mbh* in 6825-6 zu ergänzen, wie auch der einschlägige Bezug *bhautika* in 6828-9. Unbeschadet sonstiger Anwendung, und vielleicht umgekehrt als

in der ärztlichen Nomenklatur, scheint *dhātu* als Fachausdruck in der Physiologie des *MBh* jünger zu sein, wie er anschliessend in 6826-7, 6839 und 6864 gebraucht wird. Daher ist ein ärztlicher Einfluss hierbei annehmbar, wenn auch nicht nachzuweisen. Dafür spricht aber auch, dass das System der 5 *mbh*, dessen grosse Bedeutung in XII, 9880-1 erneut betont und anscheinend von verschiedenen schulmässigen Lehren im *MBh* anerkannt ist, im Fünfersystem einen Ausbau erfährt, welcher eine mittel- oder unmittelbare Einwirkung aus Ärztekreisen nahelegt.

Diese Erweiterung erfolgte hauptsächlich nach Seiten der Sinnesphysiologie unter enger Verbindung mit psychischen Funktionen, welche bereits bei der Lehre über die *mbh* ausbildete, jedoch bisher noch nicht besonders erörtert worden sind. Eine Trennung von physiologischen und psychologischen Belangen lässt sich bei den altindischen Anschauungen nicht in der Weise durchführen, wie das nach modernen Prinzipien möglich ist. Zudem ist die Systematik im *MBh* nicht ganz einheitlich, wenigstens nicht in den Fachbezeichnungen. Gemeinsam ist jedoch den verschiedenen Lehren eine Entwicklungsreihe, in welcher die bisher besprochenen *mbh* nur einen Anteil oder Stufe bilden. Die einzelnen Stufen dieser Ordnung, welche in XII, *11558-66* als Strahlen (*sarga*) bezeichnet werden, sind die folgenden neun; sie gehen aus der *prakṛti* (Ursache) hervor, aus der sogenannten Urmaterie :

Aus dem Unentfalteten (*avyakta* = *prakṛti*) entsteht nacheinander :

I. Der grosse (*mahant*) *ātman* [= *buddhi* oder Erkenntnis].
II. Der *ahaṃkāra* (Ich-Macher) dessen Körper oder Wesen die *buddhi* ist.
III. Das *manas* (Denken), unter Bezug zu den folgenden.
IV. Die 5 *mbh*.
V. Die 5 *viśeṣa*s (Besonderheiten der 5 *mbh*).
VI. Die 5 *indriya*s (Sinnesvermögen oder Sinnesorgane).
VII. Die 5 *aindriyaka*s (die mit den *indriya*s in Verbindung stehen).
VIII. Die Strömung (*srotas*), welche aufwärts und quer verläuft.
IX. Die Strömung, welche abwärts gerichtet ist.

Die beiden letzten, hier angefügten Gruppen betreffen Lehren, welche nicht regelmässig erwähnt werden, vgl. III, *13974*, XIV,

1011, *1038*, *1054*, und welche mit Lehren über die Herzfunktion zusammenhängen. Von den vorlaufenden und regelmässig zusammenhängenden Reihen werden I-II und IV ursprüngliche oder wirkende (*prakar*), III und V-VII umgewandelte (*vikar*) Formen genannt (*11552-5*). Damit ist eine Aussonderung der Sinnesbelange gegeben, die *manas* als 6. Sinn bewertet, z.B. in I, *113* oder XII, *7077*. Im *MBh* stehen diese letzten Gruppen in oftmaliger und ausschliesslicher inhaltlicher gegenseitiger Abhängigkeit, wie sie auch in der alten Fachmedizin auftaucht. Eine jüngere Textstelle, *SuS śārīra* 1, *14*, betont sogar ausdrücklich diese für die Medizin beachtenswerte Sonderstellung. Die einzelnen Anteile der vier Fünfergruppen bieten nach XII, *11553-5* folgende schematische Übersicht:

IV.	Raum	Wind	Feuer	Wasser	Erde
	ākāśa	*vāyu*	*jyotis*	*ap*	*pṛthivī*
V.	Ton	Berührung	Anblick	Geschmack	Geruch
	śabda	*sparśa*	*rūpa*	*rasa*	*gandha*
VI.	Ohr	Haut	Auge	Zunge	Nase
	śrotra	*tvac*	*cakṣus*	*jihvā*	*ghrāṇa*
VII.	Rede	Hand	Schoss	After	Fuss
	vāc	*hasta*	*upastha*	*pāyu*	*pāda*

Die oben gegebenen Übersetzungen sind teilweise sehr behelfsmässig; es lässt sich nicht jede Färbung der Form und Inhalt der einzelnen Bezeichnungen in einem Wort wiedergeben. So umfasst beispielsweise in V *rūpa* die Bedeutung von Gestalt und Farbe. In VII würde moderne Auffassung den Mund bei *vāc* erwarten, welche als Rede die Funktionsbewertung der Inder andeutet. Das funktionelle Moment müsste auch bei der Reihe der Sinne mehr zum Ausdruck kommen; einige Eigenarten der indischen Einstellung werden sich nachfolgend noch zeigen. Auf einen umfassenden Abschluss für die kritische Untersuchung solcher indischer Besonderheiten muss hier als zu weit führend verzichtet werden. Die Anordnung der Einzelglieder der Reihen entspricht nicht immer ihrer gegenseitigen Abhängigkeit; auch die einzelnen Namen weichen ab, ohne dass die wesentliche Systematik der vier Gruppen dabei zerstört wird. Diese Regel

schliesst aber nicht aus, dass andere Doktrinen das System durchdringen, wie in XII, *8740*, *10494-6* oder *6840-45*, welch letzte Gliederung nachfolgend benutzt wird:

Raum	Wind	Feuer	Wasser	Erde
6842	*6844-5*	*6841*	*6843*	*6840*
Ohr		Auge	Schleim	Haut
śrotra	*prāṇa*	*cakṣus*	*śleṣman*	*tvac*
Nase		Glanz	Galle	Fleisch
ghrāṇa	*vyāna*	*tejas*	*pitta*	*māṃsa*
Mund		Wärme	Blut	Knochen
āsya	*apāna*	*uṣman*	*śoṇita*	*asthi*
Brust		Verdauen	Schweiss	Mark
hṛdaya	*samāna*	*jar*	*sveda*	*majjā*
Bauch		Zorn	Fett	Sehne
koṣṭha	*udāna*	*krodha*	*vasā*	*snāyu*

Die *mbh* der obersten Querreihe bilden hier offenbar die auslösenden Stützpunkte für eine medizinische Systematik. Gemäss dem *mbh* Raum betrifft die 1. senkrechte Reihe die Hohlräume des menschlichen Körpers. Die 4. Kolumne des Wassers bezieht sich auf flüssige, während feste Anteile des Leibes der Erde angefügt sind. Es ist hierbei beachtenswert, dass die Anteile des *Tridoṣa*-Systems (vgl. S. M8) — Wind, Galle, Schleim — nicht vereinigt erscheinen und dass entgegen dem engen Bezug der Galle zum Feuer in der Fachmedizin (vgl. *Janus* 1934) *pitta* der Flüssigkeits-Reihe eingefügt ist. Das Feuer bewahrt in seiner Kolumne den Bezug zu Lebensäusserungen nach althergebrachten Anschauungen, welche sich in Richtung energetischer Funktionen auffassen liessen. Zwischen letztgenannten und den Hohlräumen bildet die Wind-Kolumne ein vermittelndes Zwischenglied. In ihr ist das System des *prāṇa* (Atem) untergebracht, welches bereits als Fünferreihe im *Atharvaveda* auftaucht und in seiner Entstehung sogut wie ungeklärt ist. Deshalb wird es hier nicht weiter erörtert trotz seiner Wichtigkeit in den Lehren des *MBh* und der Fachmedizin. Endlich wird nachfolgend ein

Beispiel der Kombinationen und Verwerfungen zum System der *mbh* angefügt, wie es XII, *7074-6* und (*10494-6*) bietet :

Raum	Wind	Feuer	Wasser	Erde
7074b	*7075a*	*7075b*	*7076a*	*7076b*
Ton	Berührung	Anblick	Geschmack	Geruch
Ohr	Haut (*prāna*)	Auge	Zunge	Nase
Höhle *kha*	Bewegung *ceṣṭa*	Reife *pāka*	Nasses *kleda* (*sneha*)	Festes *śārīra*
(*10494a*)	(*10496a*)	(*10495a*)	(*10494b*)	(*10495b*)

Wird von der Einsprengung des (*prāṇa*) in (*10496a*) bzw. der eingefügten Variante dieser Theorie abgesehen, so stimmen die ersten drei Querreihen mit dem zuerst zitierten Paradigma XII, *11553-5* (vgl. S. M. 12) überein, wie diese drei Fünfergruppen regelmässig in den Texten des *MBh* sich finden, bereits I, *3614-5*. Die letzte Querreihe ist weniger gebräuchlich als die Reihe VII des Standard-Beispieles. In engster Abhängigkeit stehen die beiden ersten Querreihen, die der *mbh* und ihrer Eigenschaften, welche ihrerseits ein Verband-System bilden, welches III, *13925-6* oder XIV, *1406-20* zeigt :

	Raum	Wind	Feuer	Wasser	Erde
Ton	+	+	+	+	+
Berührung		+	+	+	+
Anblick			+	+	+
Geschmack				+	+
Geruch					+

In dieser Tabelle besteht unter wechselseitiger Staffelung eine Abhängigkeit von der Entwicklung der *mbh*, auch einschliesslich der Abbau-Lehre in XII, *8559 ff.* : Wenn der Geruch der Erde vom Wasser aufgenommen wird, so verfällt die Erde infolge von Verlust des Geruches folgerichtig der Auflösung. Und in dieser Weise vollzieht sich dann weiter die Auflösung der Reihe; das tiefere *mbh* geht zugrunde wegen Verlust seiner Eigenschaft und letzte wird von dem nächst höheren *mbh* aufgenommen, bis zur

schliesslichen Lösung im *Brahman*. Diese Erweiterung der *mbh* erscheint hier neuartig zu sein; sie wird oft an dem — auch sonst geläufigen — Beispiel der Schildkröte erläutert, welche ihre Glieder ausstreckt und einzieht. Es schimmert hier ein Gründprinzip indischer Lebensauffassung durch, wie dieses auch eine andere Anwendung zeigt. Die Lehren des *Pañcaśikha*, welche Bezug zur *CaS* haben, erfahren in XII, *7821* eine Zusammenfassung : Sinne (*indriya*), Denken (*manas*), Wind (*vāyu*), Blut, Fleisch, Knochen gehen eins nach dem anderen zugrunde und in ihren betreffenden *dhātu* ein. Dieser beachtliche Lehrsatz, dessen abschliessende Untersuchung zu weit hier führen würde, dürfte in seinen Grundzügen nach dem Vorgang verständlich sein. Nebenherbemerkt trägt *Pañcaśikha* in den auffälligen Ausführungen *7891-2* offensichtlich einen Sinn-Namen, der Mann mit den 5 Haarschöpfen, in Anspielung auf seine Fünfer-Systematik; und dass diese Schöpfe als Flammen zu verstehen sind, entsprechend der alten Feuerlehre, muss nach *11885* in weiteren Kreisen bekannt gewesen sein.

Der Fachausdruck, welcher die Eigenschaft der *mbh* (Ton, Berührung usw.) umschreibt, und welcher nicht selten auch für andere Reihen verwandt wird, ist regelmässig *guṇa*. Seine ursprüngliche Bedeutung als Strick o. dgl. ist noch zuweilen nachweisbar (XII, *10525* u. *13786*), auch erinnern daran noch allfällige Vergleiche mit dem Faden einer spinnenden Raupe oder Spinne. Im allgemeinen ist jedoch der Eigenschafts-Begriff in einer Richtung entwickelt, wie ihn die spätere *Sāṃkhya*-Philosophie bietet. Neben der Standard-Bezeichnung durch *guṇa* werden in gleichem Sinne auch andere Ausdrücke gebraucht, wie *viśeṣa* (Besonderheit), *lakṣaṇa* (Merkmal), am häufigsten Worte, welche gewöhnlich mit „Objekt" übersetzt werden, *viṣaya* (Gebiet) und *artha* (Ziel). Besonders durch *artha* ist die Richtung der Sinnesfunktionen gekennzeichnet. Diese besprochenen Eigenschaften weilen nach XII, *7414* als *guṇa*s in den *mbh* und als *artha*s in den Sinnen. Letzte sind gemäss XII, *9885* die Organe zur Erkenntnis der *artha*s (= *guṇa*s, gemäss *9887*), welche durch die Sinnesorgane erreicht oder aufgegriffen werden (*upalabh*). In der funktionellen Form des sehenden usw. (*darśana* etc. in *9886*) sollen die *guṇa*s mittels der Art des Einfalles (*upapatti*) erkannt werden. Die hier skizzierten Vorstellungen entsprechen

demnach zentrifugalen Prinzipien oder einer Strahlungstheorie.

Die Sinne, die *indriyas*, sind bisher als anatomische Organe bewertet worden, obwohl in der dazu verwandten Sachlage bereits die Funktion betont erscheint. Weiter ausführende Textabschnitte halten sich auf physiologischem Gebiet. Wenn der althergebrachte Vergleich mit Pferden, Wagen und Lenker beiseit gelassen wird, so geht sonst die Darlegung meist vom Sehakt aus. XII, *9890* lehrt: Zuerst betrachtet der Mensch die Gebiete im einzelnen (das Betrachten entspricht der Causativform von *cit* = bestrahlen, womit eine grundsätzliche, oben erwähnte Vorstellung charakterisiert ist). Dann folgt die Auswertung (dieser Bestrahlung) durch das *manas* und die *buddhi*, welche als entscheidend gilt. XII, *11585* erklärt: Denn nicht die Sinnesorgane (*indriya*) sehen, sondern das *manas* sieht hin; das Auge sieht den Anblick mit Hilfe des *manas*, nicht mittels seiner selbst (wörtlich: durch das Auge). Oder nach XII, *8991*: Das Auge sieht, das *manas* bedenkt, die *buddhi* erkennt und der *kṣetrajña* ist Zuschauer. Dieses Paradigma des Sehens, seine förmliche Übernahme auf die anderen Sinnesgebiete unter Vernachlässigung von Sonderheiten, endlich die gestaffelte Anordnung bis zum Abschluss des sinnenphysiologischen Ablaufes zeigt, dass der Schwerpunkt der Betrachtungsweise der Altinder nicht auf anatomischem sondern (psycho-) physiologischem Gebiet lag. Aus diesem Gesichtswinkel heraus werden die Organe als Erkenntnis-Sinne (*jñāna-* oder *buddhi-indriya*) bezeichnet unter Gegenüberstellung zu den Tat-Sinnen (*karma-indriya*), wie Hand, Fuss usw. Eine solche Unterscheidung ist z.B. in XIV, *750 ff.* ähnlich ausgeführt durch: tuend (*karaṇa*), Täter (*katar*) und Tat (*karman*). Die Organe werden auch Standorte (*adhiṣṭhana*) der *buddhi* genannt, sind nach XII, *8742* als sehende Sinne (*darśana-indriya*) Tore oder nach XIV, *1155-8* Stromöffnungen (*srotas*), welche den grossen *ātman* im Herzen umgeben. Die Zahl solcher Öffnungen oder Röhren, in XII, *7780-3* als *dhamani* bezeichnet, wird am Herz zu 10 verdoppelt gegenüber einer Röhre (*sirā*), welche *manas* führt und von welcher die übrigen ausgehen; dabei wird offensichtlich als Paradigma der Sehakt erwähnt bei eine Röhre, welche zum Auge Feuer-*guṇa* leitet. Auf derartigen Anschauungen beruht auch die Herz-Lehre in *CaS sūtra* 30, *1-13*, welche nichts mit einem Blutkreislauf zu

tun hat. Und um wenigstens auch auf ein Beispiel für die Sinnes-Systematik in der Fachmedizin zu verweisen, kann *CaS sūtra* 8 genannt werden.

Ähnlich den Erörterungen physiologischer Momente sind die Belange der Pathologie dem allgemeinen Inhalt der Texte eingegliedert. Die Erwähnung von Kranken geschieht im Rahmen von anderen Bedrängten und Hilfsbedürftigen, wie Elenden, Blinden, Lahmen, Hungrigen, Greisen, Schwachen, Kindern, Frauen usw. Solche Zusammenstellungen finden sich bereits in den vedischen Überlieferungen angedeutet, wurden von anderen, auch Rechtlehrenden aufgenommen und anscheinend besonders in buddhistischen erhalten (vgl. Sudhoffs Archiv, 1930, *146 ff.*). Eine häufige Bezeichnung im *MBh* für krank ist *ātura*, schon in den Veden gebräuchlich, wie auch die dort übliche verneinende Umschreibung für den Gesunden als Nicht-krank beibehalten ist. Ebenso ist — gleichfalls nach vedischem Vorgang — die Krankheit oft Gruppen verschiedenen Ungemachs eingereiht, meist *vyādhi* genannt, wie in altertümlich anmutenden Teilen der Fachüberlieferung, zuweilen auch *roga*, wie hauptsächlich in der Medizin bezeichnet, oder *duḥkha* (mit seinem Gegensatz *sukha* auch in der *CaS* gebraucht), und *kleśa*, welcher der *Yoga*-Nomenklatur angehört.

Wie eingangs schon angedeutet, könnte die Einfügung von Krankheiten bei Erlösungslehren philosophischen Charakters überraschen. Das geschieht aber im *MBh* sogar unter gewisser Betonung (wie in den Veden) in der Zusammenfassung längerer Ausführungen, wie z.B. in XII, *7150*, *7173*, *8477*, *9754*, *10271* usw. Das Freisein von Krankheit (*anāmaya*) gilt unter anderem als eine Umwandlung des *Brahman*, gemäss : V, *1713-4*.

Bei einer Frage nach ärztlichem Einfluss dürfte die Erwähnung der Götterärzte, *Nāsatya* und *Dasra*, (z.B. in XII, *12917*) geringe Bedeutung haben, desgleichen die Nennung des Arztes zwischen Schutzbedürftigen unter der nicht ganz eindeutigen Bezeichnung *vaidya*. Auch die Nennung *suśruta* (wörtlich : berühmt) in XIII, *254* bietet keine Sicherung für einen Bezug zu dem sagenhaften Autor der *SuS*. In XII, *7663* wird ein *Kṛṣṇātreya* als Vertreter der Heilkunde (*cikitsita*) angeführt, dessen Name auch in *CaS sūtra* 11, *65* oder *cikitsā* 15, *129* vorkommt. Seitens des Kommentators *Cakrapāṇidatta* wird dieser in letztem Beleg von dem

Hauptlehrer in der *CaS*, dem *Ātreya* oder *Punarvasu* unterschieden; in dem ersten Nachweis erscheint sein Name in einem philosophisch gefärbten Abschnitt der *CaS*. Diese Unterlagen liessen sich dahin verwerten, dass jener schwarze *Ātreya* in einer Zeit lebte, als der Arzt sich aus dem Kreis von Allgemeinwissenschaftlern sonderte, falls nicht nur ein berühmter Name übernommen ist, wie anscheinend oft in den indischen Überlieferungen. Diese Unsicherheit besteht bei vielen Namen im *MBh* und kann leicht zu Trugschlüssen verleiten. Beispielsweise bei *Bharadvāja* (vgl. S. M9), einem gewichtigen Autor in der *CaS*, welcher bis in die arische Vorzeit zurückdatiert werden kann. Im *MBh* (XII, *7662*) ist er der Vertreter der Kriegswissenschaft gegenüber dem der Heilwissenschaft, *Kṛṣṇātreya*. Mit dem Verweis auf diese Wissenschaften, den 4 Nebenveden (*upaveda*, vgl. III, *450*) wird der ärztliche Bezug für das *MBh* doch ein engerer. In II, *442* wird die Medizin mit ihrem traditionellen Beiwort: achtgliedrig erwähnt, ebenso wird der *āyurveda* in XII, *13246* aufgezählt und in *13127* mit den im *MBh* herrschenden Disziplinen, *yoga* und *sāṃkhya*, verbunden. Aus einer der Grundtendenz entsprechenden Einstellung erfolgt sogar in XII, *12540-1* eine kurze Polemik gegen Ärzte, so dass ihr Einfluss nicht gänzlich bestritten werden kann.

Einwandsfreier wird die Frage durch den Nachweis besonderer medizinischer Theorieen gelöst. Gemäss XII, *7779* ernähren die Säfte (*rasa*) durch ein Adergefecht den Körper, dessen Anteile — Blut, Haut, Fleisch, Sehnen, Knochen, Mark — aufgezählt werden. Und vor diese Reihe ist der Wind (*vāta*, eine Bezeichnung, welche sonst im *MBh* selten gebraucht wird), Galle (*pitta*) und Schleim (*kapha*) gesetzt, also jene Fachausdrücke, welche als Krankheitsstoffe (*doṣa*) in der Fachmedizin bekannt sind und dort nach der Regel im Gegensatz zu den physiologischen Anteilen stehen, auf welche sich die *dhātu*s beziehen. Im *MBh* werden wiederholt die *doṣa*s und *dhātu*s getrennt angeführt; in III, *13968* oder XII, *6874* sind die Säfte (*rasa*, sc. der Nahrung), *dhātu*s und *doṣa*s gleichmässig der Wirkung des Körperfeuers ausgesetzt. Nach XIV, *465* werden die *doṣa*s durch ungesunde Lebensweise erregt, ähnlich einer übermässigen Körper-Wärme (*uṣman*) gemäss *469*. Jedoch werden in XII, *13244-6* Galle, Schleim und Wind ausdrücklich als *dhātu*s bezeichnet, was in

der Frühzeit ungewöhnlich ist. Hier besteht aber bei der Verherrlichung des Gottes *Nārāyaṇa* und der Erlösung durch seine Hilfe eine gewisse Zwangslage. Es spielen auch Vorstellung einer Vergeltungslehre aus früheren Dasein hinein. Daher entstehen aus den früheren Werken (*karmaja*) diese *dhātus*. Bei der Bezeichnung *dhātu* liegen hier also ähnliche Vorstellungen zugrunde, wie sie bei der Metamorphose der physiologischen Reihe entwickelt worden sind. Darum wird der Gott mit dem Namen *Tridhātu* verbunden, und da dies nach *13246* von Ärzten geschieht, so muss auch angenommen werden, dass dort die Parallele zwischen *doṣa* und *dhātu* aus solchen Gesichtspunkten entstanden ist. In XII, *6937* ist Schleim und Galle eingereiht zwischen Schweiss, Harn, Kot und Blut; auch hier ist der Bezug zum Körper und dem Wechsel ein absprechender. Ähnlich motiviert XIV, *1158*, in der Übersetzung DEUSSEN-STRAUSS nach der alten Bombay-Ausgabe: „dreigrundstoffhaft [Schleim, Galle, Wind]", während der südindische Text (Bombay 1909) wahrscheinlich korrekter bietet: sieben-*dhātu*-haft. Ob hier Mangel an kritischem Text oder Verständnis für medizinische Ausdrücke vorliegt, lässt sich vorläufig nicht entscheiden. Zudem waren Verwerfungen möglich, wenn aus der Fünferreihe der *dhātus* oder *mbh* der Raum (Höhlen) und Erde (feste Körperanteile) fortgelassen wurden, wie das XII, *6864* (*6840*, *6842*) als Dreier-System andeutet. Eine derartige Sonderung trat im späteren *Vedānta* auf, dessen Vorstufen hier und da im *MBh* durchschimmern. Endlich kann auch lediglich die Vorliebe für Systematik die Zahl aus anderen Dreier-Systemen der Veden übernommen haben. Jedenfalls muss als wörtlicher und grundsätzlicher Begriff für *doṣa* der des Fehlers angesehen werden, so z.B. durch Blut, Harn und Kot in XII, *10649* ohne medizinische Theorie charkterisiert, oder in VI, *1330* durch die Verbindung mit *duḥkha*.

Aus dieser allgemeinen Pathologie heben sich spezielle Momente ab. Sie beginnen mit empirischen Bewertungen in Korrespondenz mit der schon in den Veden betonten hohen Einschätzung der Lebensdauer, unter Beobachtungen von Alterserscheinungen, die in XII, *10650-1* und anderen Textstellen eingehend beschrieben werden. In XII, *9389* werden die Krankheiten zu 101 normiert, wie aus vielen indischen Überlieferungen bekannt; diese Zahl

ist wohl aus dem Zusatz einer 1 nach der unheilbedeutenden 0 am Schluss der runden 100 entstanden. Solche volkstümlichen Einstellungen liegen wohl auch den Legenden zugrunde, welche unter theoretischen Erweiterungen in die Fachmedizin teilweise übergegangen sind, und nachfolgend aus den *MBh*-Texten kurz skizziert werden.

XII, *9155-9228*: Der Gott *Prajāpati* lässt infolge Zorn (*roṣa* = *tejas*, *9166*) aus seinen Körper-Höhlen oder Öffnungen (*kha*) das Feuer hervorbrechen, welches die gesamte Welt brennt. Er zieht dann das Feuer wieder in sich zurück; dafür kommt ein Weib hervor, welches als Tod (*mṛtu*) alle Wesen vernichten soll. Aus ihren, bei der Verweigerung dieser Aufgabe, vergossenen Tränen-Tropfen und Tränen-Strömen entstanden die Krankheiten (*vyādhi*).

XII, *13219-22* vermittelt die *Yakṣman*-Legende, ähnlich in den *Brāhmaṇa*-Texten des schwarzen *Yajurveda* (*Taittirīya-Saṃhitā* II, 3, 5; 5, 6): Der Mond, *Soma*, begeht ein Eheunrecht durch Vorzug der *Rohinī* vor ihren (hier) 26 Schwestern, den Sternen der Mondstationen, den Töchtern des *Dakṣa*. Weil er nicht gleichmässig (*sama*, im Wortspiel zu *Soma*) verkehrte, wird er vom Krankheitsdämon *Yakṣman* befallen, welcher im *Atharveveda* und *Yajurveda* auch *Jāyenya* oder *Jāyānya* wegen seines Ursprunges durch die Frau (*jāyā*) genannt wird. *Soma* schwindet oder nimmt ab (*kṣi*) durch den *Yakṣman*, wird aber schliesslich durch ein Bad im westlichen [!] Goldsee geheilt und vom Übel (*pāpman*) erlöst. Weil *Soma* wieder leuchtend wurde (*avabhās*), wurde dieser See als Glanz (*prabāsa*) bezeichnet. Das Motiv dieser Legende entspringt somit zum Teil der Lichtlehre der Mondphasen, hat Bezug zum Geschlechtsleben, aber nicht zur Schwindsucht im Sinne der Tuberkulose.

XII, *10127-10270* führt die *Jvara*-Legenden aus, welche mannigfach überliefert sind (ähnlich in *Taittirīya-S.* II, 5, *2*): *Jvara* ist eine allgemeine Bezeichnung für Krankheit, wie zuweilen auch noch in der Fachmedizin. Da nach arischen Anschauungen alle Krankheiten böse Feuer waren, so ist der Fieberbegriff erst sekundär, wenn auch früh empirisch begründet. Das Feuer (*tejas*) des Gottes *Śakra* (= *Indra*) fährt als *Jvara* in den Dämon *Vṛtra*, den Hauptfeind der Götter, so dass er Anzeichen bietet wie Glutmaul, Verfärbung, Gliederzittern, Schnaufen,

Haarsträuben, Ächzen usw., *Śakra* schleudert dann noch den Blitz (*vajra*) gegen *Vṛtra*, welcher von *Jvara* bereits geschüttelt wird. Darauf fährt aus dem Körper des Dämons die *Brahmavadhyā* heraus, deren Beschreibung an die furchtbaren Gottheiten des Tantrabuddhismus erinnert. *Brahmavadhyā* bedeutet : tödlich dem *brahmán*, d.h. dem, welcher das *bráhman* (das Feuer, vgl. S. M. 9) besitzt, also mordlustig gegen den *Śakra*, welcher über das Blitzfeuer verfügt (*vajrin*, *10157*) und welcher dann auch von der Dämonin verfolgt wird. Wenn ihr Name später (*10163*) in *Dvijapravara-vadhyā* (*dvijapravara* = der beste der Zweimalgeborenen, d.i. der Brahmanen) umgestaltet wurde, so beruhte das wohl auf Priester-Einfluss. *Śakra* wird schliesslich von der Dämonin ergriffen, seines *tejas* beraubt und wendet sich um Hilfe an *Brahman*. Letzter weist der *Brahmavadhyā* anderen Aufenthalt an : 1. im Feuer (*agni*), 2. in Pflanzen, 3. in Weibern, 4. im Wasser (*10170-97*). Die Variante *13217* gibt als Sitze an; Weiber, Feuer, Bäume, Kühe. Ein unrechtes Verhalten der Menschen gegenüber diesen Zwischenträgern löst Erkrankungen aus. Aus dem Blute des erschlagenen *Vṛtra* entstanden die [nicht näher zu bestimmenden] *Śikhaṇḍa*s, welche von den Brahmanen nicht genossen werden dürfen. Ab *10208* ist eine andere *Jvara*-Legende angeschlossen. Von der Stirn des *Śiva* fällt ein Schweisstropfen zur Erde, aus welchem ein Feuer aufflammt. Als Glut (*gharma*) des Gottes entsteht hieraus der Dämon *Jvara*. Auch dieser *Jvara* wird aufgeteilt, in einzelne Tierkrankheiten und Formen (wie z.B. Steinsalz usw.), worunter sich vielleicht volkstümliche Krankheitsnamen verbergen.

Gegenüber solchen Legenden volkstümlichen Ursprunges hebt sich scharf eine Reihe von Krankheitsnamen in XII, *11267-8* ab : *śīrṣaroga* (Kopfkrankheit), *akṣiroga* (Augenkrankheit), *dantaśūla* (Zahnschmerz), *galagraha* (Kehlwürgen), *jalodara* (Wasserbauch), *tṛṣaroga* (Durstkrankheit), *jvaragaṇḍa* (Fieberknoten), *viśūcika* (Brechdurchfall), *śvitrakuṣṭha* (weisser Aussatz), *agnidagdha* (Feuerbrennen), *sidhma* (fleckiger Aussatz), *apaśmāra* (Gedächtnisschwund, Fallsucht). Der Beleg erweckt den Eindruck der Herkunft aus einer ärztlichen Fachlehre, welche jedoch bisher nicht nachgewiesen werden konnte; daher sind die Übersetzungen teilweise behelfsmässig.

Bei den Heilmassnahmen ist gemäss althergebrachten An-

schauungen der Gott ein Helfer; so in XII, *10433* unter vielen anderen Eigenschaften *Śiva* der Krankheitsvertreiber (*vyādhihar*) oder nach XII, *7666* stammt das beste Heilmittel von *Nārāyaṇa* bezw. *Viṣṇu*, welcher das *brahman* kennt ! Beim Scheeren, Niesen, Baden, Essen oder am Krankenlager wurde Gesundheit gewünscht (XII, *7054-5*). Augensalben waren bekannt (I, *64*), wie auch eine Anzahl von kosmetischen oder hygienischen Massnahmen (XII, *7034 ff.*), dgl. solche für Diäthetik (XII, *11154*, XIV, *462-70*). Ferner wurde eine Prognostik (Vorzeichen des Todes, *ariṣṭa*, XII, *11710-19*) berücksichtigt, wie in den Traumlehren und in der Fachmedizin. Von Heilmitteln werden oft die Kräuter (*oṣadhi*) genannt; ihre Verbindung mit Würzen (*kaṣāya*) und zerlassener Butter (*sarpis*) kennzeichnet den engen Zusammenhang mit Nährmitteln, welcher bereits in den Veden nachweisbar ist und sich ausschlaggebend in der Fachtherapie erhalten hat. Lusthaine, Gebäude und Krankheitsheilmittel werden in XII, *8695* hinter einander aufgezählt. Derartige Belege erinnern an buddhistische Überlieferungen (vgl. Sudhoffs Archiv 1930, *135 ff.*), ebenso an ihres Heilgottes *Bhaiṣajyadeva* Kennzeichen, die Myrobalanen-Frucht (*āmalaka*), welche in XII, *8319* [beachtenswert] *Kāla*, in *11654* der *Yājñavalkya* in der Hand trägt.

Nach arischen Vorstellungen beruhte die Heilwirkung auf Feuer. Damit im Einklang, wird in XII, *12918* das Kraut parallel dem *tapas* gesetzt, dem Feuer in den *Yoga*-Anhängern; oder nach XIV, *1440* enstehen oder wurzeln die Kräuter, Heilmittel und Wissenschaften im *tapas*. Zu besonderen Zwecken benutze der *Yogin* antreibende Mittel (*saṃcodana*) in seiner Atemtechnik gemäss XII, *11378*, *11685*, auf welche auch die alte Fachmedizin anspielt. Derartige Praktiken lösten Zustände aus, welche in XII, *8786-91* geschildert werden und aus einem modernen psychiatrischen Gesichtswinkel mit einer Aura und folgenden deliranten Formen verglichen werden können. In XII, *11868* wird berichtet, dass die *Yoga*-Anhängerin *Sulabhā* mit ihren Augenstrahlen den Fürsten bei ihrem Besuch bindet. Letzter glaubt an eine erotische Beeinflussung, so dass allgemeinere Kenntnisse über Blicksuggestion [welche hier wohl vorliegt] nicht angenommen werden können.

Bei den letzten Hinweisen ist die Untersuchung wieder auf ein Gebiet übergeglitten, welches psychische Funktionen betrifft.

Sie werden zum Schluss betrachtet in medizingeschichtlichem Rückblick, welcher einige Beachtung verdient. In den skizzierten Krankheitslegenden (vgl. S. M. 18-20) ist die arische Grundlage noch deutlich erkennbar, Feuerlehre und Wertung der Krankheiten als Personen. Nach XII, *10138-46* brechen glühende und gleissende Feuerbrände und sein sehr grausig anzusehendes Gedächtnis (*smṛti*) aus den Flanken des *Vṛtra* hervor, welcher von *Jvara* gänzlich besessen ist. Jedoch kurz zuvor ist die Freude der Götter gegenübergestellt dem Gedächtnisverlust ihrer Feinde. Hier sind also Gefühlsmomente betont und in ihrer Benutzung eine erkenntnistheoretische Richtung der Abstraktion angedeutet, wie sie beispielsweise in der alten Fachmedizin bei der Bedeutung des Gedächtnisverlustes (*apaśmāra*) erkennbar ist gegenüber den Geisteskrankheiten durch Dämonen (*bhūta*).

Bei einer Umschau nach den Trägern solcher Entwicklung drängt sich im *MBh* der *Yoga* und das *Sāṃkhya* in den Vordergrund. Unter diesen beiden Bezeichnungen lassen sich hier nicht abgeschlossene philosophische Systeme annehmen, sondern Sammelnamen für zwei prinzipielle Richtungen, welche unter teilweise recht verschiedenartigem Bezug durch die Texte laufen. Kurz zusammengefasst, bildet der *Yoga* hauptsächlich einen Betätigungs-Antrieb zur Erlösung auf theistischer Basis, während das *Sāṃkhya* eine reflektierende Komponente darstellt oder ein System der Betrachtung durch Berechnung, wie seine Definition als *parisaṃkhyādarśana* in XII, *11409* aufgefasst werden kann. Ähnlich ist *saṃkhya* (= berechnend) und die abgeleiteten Bezeichnungen regelmässig in den nicht-philosophischen Texten der *CaS* zu verstehen. Die Unterstellung eines ausgebildeten philosophischen Systems, wie das spätere *Sāṃkhya* es bietet, ist nicht haltbar (vgl. „On *sattva*, *rajas* and *tamas* in the old Indian medicine" Journ. of Ayurveda 1934. Dieser Aufsatz ergänzt auch die weiteren Ausführungen hier).

XII, *9352-3* zählt von Kranken auf Blinde (*andha*), Taube (*vadhira*) und Über-erregte (*ud-mad*), welchen die Götter die [Sinnes-] Tore geschlossen haben. Althergebrachte empirische Wertung ist hier vereinigt mit solcher auf psychischem Gebiet. Das letzte wird systematisch auch oft als *mānasa*, d.h. dem *manas* angehörig, erklärt und gegenüber körperlichen (*śārīra*) Leiden unterschieden, wie z.B. in XII, *6879*, *7460*, *12492-3*, *12514*.

Diese Unterscheidung ist principiell auch in der alten Fachmedizin durchgeführt.

Das Lehrgespräch zwischen *Bhṛgu* und *Bharadvāja*, welches bereits S. M9 benutzt wurde, beginnt in XII, *6775* mit dem Hinweis, dass der Gott in seiner ursprünglichen Form *mānasa*, d.h. geistig, genannt wurde; er strahlte den Grossen (*mahant* sc. *ātman*) aus, letzter den Ichmacher (*ahaṃkāra*), welcher dann die *mbh* hervorbringt. Aus den *mbh* entsteht die Kraft (*bala*) in Form eines Lotos (eine sehr beliebte Vorstellungsform der Physiologie), aus welchem *Brahman* wird. Der Abschluss des Textabschnittes (*6802*) schliesst den Kreis damit, dass *mānasa* in *Brahman* eingeht. Mit *6805* wird das Thema erneut angenommen, welches von *mānasa* [also *Brahman*] durch seinen Geist (*manas*) die Welt entstehen lässt, was dann in Einzelheiten der *mbh*-Lehre ausgeführt wird. *Bharadvāja* wendet hierbei *6883-97* ein, warum ausser den 5 *mbh* noch als 6. das Leben (*jīva*) angenommen werden solle; denn die Körper stürben und nur der Samen (*bīja*, nach alter Anschauung ein Feuer) entwickle sich weiter. Gegenüber dieser älteren empirischen und theoretischen Einstellung des *Bharadvāja* streitet *Bhṛgu* die Bedeutung des Feuers keineswegs ab sondern betont sie sogar, zumal im Abschluss seiner Belehrung, in der Gleichsetzung mit dem Leben (*6898-6929*). Er flicht jedoch entwickeltere Ansichten ein, wie z.B. eine Gleichung von *ātman*, *mānasa*, *Brahman*, *kṣetrajña* und dem höchsten (*parama*) *ātman* (*6920-1*) und schliesst (*6929*), dass das geistige Feuer (*mānasa agni*) in den Körpern das Leben ist als das höchste Selbst (*adhi ātman*). Auch der Lehrabschluss in *6949* erkennt die Spitzenstellung von *mānasa* im System an, welche sich auf alten Anschauungen aufbaut.

Anderseits gilt, in Anlehnung an eine erweiterte Lehre von den *mbh*, als 6. Sinn das *manas* (vgl. S. M. 11) und wird in dieser Stellung als Erkenntnis-Sinn (*jñāna-indriya*) durch seinen Bezug zur Kraft (*bala*), als dem 6. Tat-Sinn (*karma-indriya*) gesichert, wie XII, *7950* von *Pañcaśikha* gelehrt wird (vgl. auch *9895*); *manas* ist hierbei an die untere Grenze des psychischen Aprates gerückt. In XII, *7935* wird der Lehre von den *mbh* vorausgeschickt, dass der Mensch die Summe von Körper, Sinnen und *cetas* bilde, wobei der letzte Ausdruck offensichtlich statt *manas* gebraucht ist, ähnlich wie *citta* in Zusammenhang mit

den *mbh* seinen Platz einnimmt in *7940*, *7953*, *7964* und *7967*. Endlich erklärt *7950* die Angliederung der 5 *mbh* als Zustand (lokativ) des *cetas*. Nach der sprachlichen Ableitung jener Worte von *cit* = strahlen, kann unter *cetas* (das Strahlen) und *citta* (das Gestrahlte) eine Funktionsform des *manas* verstanden werden, im Einklang mit den Grundanschauungen der Sinnesphysiologie. Daher wird in *9891* gelegentlich der Erwähnung des *manas* die Summe der Sinne als gestrahlt (*citta*) bezeichnet. Und in ähnlicher Weise kann *cetanā* in *7939*, *7940*, oder *10520* als Strahlung bewertet werden. Da technische Ausdrücke mit der Herleitung von *cit* im *Yoga* bevorzugt werden, so ist für das *MBh* die Quelle damit angedeutet. Dahin weist auch *8959*, wo der *Yogin* das *citta* in das *sattva* eintreten lässt und beruhigt. *Sattva*, *manas* und *cetas* sind in einer korrespondierenden Stelle in der alten ärztlichen Fachüberlieferung (*CaS sūtra* 8, *4*) aber Synonyma.

Am bekanntesten ist jedoch die Bezeichnung *sattva* durch die ausgebildete *Sāṃkhya*-Philosophie geworden, in welcher es die Reihe ihrer drei spezifischen *guṇa*s eröffnet. Diese 3 Konstituenten der Urmaterie, nämlich *sattva*, *rajas* und *tamas*, werden meist mit Güte, Leidenschaft und Finsternis übersetzt, als behelfsmässige Sammelbegriffe für mannigfache psychische Erscheinungsformen, welche bereits im *MBh* wiederholt in vielen Einzelheiten ausgeführt werden. Solche Schilderungen bringen auch die *Pañcaśikha*-Lehren in XII, *7954-61*; doch muss nach der Sachlage des Textinhaltes dieser Abschnit zu irgend einer Zeit nachträglich eingeschoben sein. Denn — um nur kurz zu skizzieren — der Text, welcher *7953* endet, ist in *7962* fortgesetzt, und der *Yoga*-Begriff des Strahlens steht in *7967-9* in alleinigem Gegensatz zur Finsternis (*tamas*).

Gegenüber dem *Sāṃkhya*-System, welches die 3 *guṇa*s nebeneinander stellt, findet sich im *MBh* noch eine andere prinzipielle Anschauung, in welcher *sattva* von *rajas* und *tamas* unterscheidend abgetrennt und übergeordnet ist. Eine längere Lehrerörterung schliesst in XII, *7677* damit, dass *manas* als Eigenschaft (*guṇa*) des *sattva* gilt und letztes — aus dem Unentwickelten entstanden (*avyaktaja*) — das Selbst (*ātman*) aller Wesen darstellt. Danach liegt hier für *sattva* eine Art von Seelenbegriff vor, wie er S. M. 5 bei *puruṣa* und *kṣetrajña* angedeutet wurde. Diese beiden

Ausdrücke werden schliesslich auch in XIV, *1343* mit *sattva* identifiziert nach einer Lehrmeinung, die jedoch nicht mehr anerkannt wird. Die einschlägigen Anschauungen laufen bereits im *MBh* auseinander. XII, *11955* reiht beispielsweise *sattva* zwischen *buddhi* und *ahaṃkāra* ein unter offensichtlichem *Sāṃkhya*-Einfluss. Dagegen räumt der *Yoga* regelmässig dem *sattva* eine Höchststufe ein und verbindet es infolge seiner theistischen Tendenz nicht selten mit den Göttern, wobei auch zuweilen die alte Feuerlehre durchschimmert (z.B. XII, *8747*, *9103*, *13514*). Somit ist es erklärlich, dass das Feuer (*tapas*) dem *Yogin* zum Ersatz des *sattva* in V, *1730* dient.

Den Gegensatz bilden *rajas* und *tamas*, an sich, oder in Verbindung mit den Dämonen, den Feinden der Götter, wie z.B. in XII, *13214*, *13280* oder *13474*. Die wörtliche Bedeutung von *tamas* als Finsternis begründet hinreichend diese Gegensätzlichkeit. *Rajas* ist nach XIV, *721* das erdige Rückbleibsel, die Asche (*rup*) des Feuerbrandes (gegenüber dem Qualm oder *tamas*), hat die Bedeutung der Begierde gegenüber dem ruhigen *manas* in VI, *1091* und scheint nicht selten durch den umfassenden Ausdruck des Durstes (*tṛṣṇā*) ersetzt zu sein. Die vedischen Vorstellungen zu *rajas*, welche vorzugsweise dem Makrokosmos entlehnt sind, nähern als Dunst usw. seine Bedeutung der Finsternis (vgl. z.B. die Übersetzung v. *Rgveda*, VII, 34, *16* durch Hertel, Abhdlg. Sächs. Ak. d. Wiss., 1931, *113*). Im Überblick bietet sich aber in den Schichten des *MBh*, welche dem *Yoga* nahestehen, folgende Sonderung: *Sattva* verkörpert das Gute, Ordnungsgemässe (z.B. in VI, *1240*, XII, *8773*, *9420*, *11174*, *13789*, XIV, *1042*), welches bezeichnend auch durch die Verneinung, frei von *rajas* und *tamas*, ausgedrückt wird (z.B. in XII, *11517*, *12884*, XIV, *1449*); die Vereinigung von *rajas* und *tamas* ist das Übel (z.B. in XII, *8320*, *9112*, *10823*, XIV, *982*).

Nach diesem allgemeinen Überblick bleibt die Frage, wie sich darauf hin eine medizinisch gefärbte Einstellung aufbaute. In der Einleitung zu seinem zweiten Lehrabschnitt verbindet *Pañcaśikha* in XII, *7934* das *tamas* mit dem Irresein wie mit einer Krankheit. Nach XII, *8216* beruht die Gesundheit (*ārogya*) des Leibes auf dem *sattva*-mässigen Verhalten. Eine Scheidung von geistigen und körperlichen Leiden scheint in den beiden Belegen verwischt; der Grund liegt in der theistischen Richtung. Denn VI, *1430*

teilt ein: Menschen des *sattva*, welche den *Deva*s (Göttern), solche des *rajas*, welche den *Yakṣa*s und *Rakṣas*s, und solche des *tamas*, welche den *Preta*s und *Bhūta*s huldigen. Die Vertreter der beiden letzten Gruppen, etwa Dämonen, Gespenster o. dgl., werden als die nicht-menschlichen (*amānuṣa*) gegenüber den Göttern bezeichnet in der *āyurveda*-Tradition (*SuS uttara* 60). Sie sind Personen, wie z.B. die Krankheiten der Legenden S. M. 19-20; mit anderen Worten die indische Metaphysik ist hier noch konkret.

Da aber die *MBh*-Texte einen nicht unbeträchtlichen Zeitraum der Entwicklung widerspiegeln, so kommen — nicht selten noch unausgeglichen — alltägliche Beobachtungen zur Geltung, welche mittel- oder unmittelbar theoretisch oder systematisch Förderung erfuhren. In XII, *11151-2* erklärt ein *Sāṃkhya*-Lehrer — mutmasslich *Pañcaśikha* — die 5 Fehler (*doṣa*) des Körpers (*deha*) als Liebeslust, Zorn, Furcht, Schlaf und Keuchen. Erst mit ihren Heilmitteln scheint eine begriffliche Abstraktion angebahnt zu sein; *sattva* bekämpft z.B. den Schlaf, welcher als *doṣa* gilt (*11153*, vgl. auch *7785*, *9859*), ähnlich in der Fachmedizin. Die erkenntnistheoretische Entwicklung erscheint aber unvollständig, die Ansätze begrifflicher Abstraktion können sich nicht vollständig von Realien und Körperlichen lösen. So vernichtet in XII, *7836-7* das *tamas* das Glänzende des Feuers (*tapas*) in dem *Yogin* und wird in XIV, *994* als Nacht und als Irresein (*moha*, so auch in der Fachmedizin) gewertet.

Doṣa und *roga* werden parallel verwandt (XII, *11148*, *12514*) auch bei einer Einengung durch *rajas* und *tamas* (*12288*). Gegenüber dem letzten Beleg tritt ein Atavismus in der Auffassung der Krankheiten als Personen immer wieder ein; so erscheinen *rajas* und *tamas* als Seuchen (*doṣa*) in der Stadt, als welche der menschliche Körper gemäss XII, *9125-6* geschildert wird. Diese Auffassung blieb bis in die neuere Zeit lebendig, wie das (im indischen Sinne realistische) Drama *Jīvānandana* im 18. Jahrhundert beweist. Auf dieser bunten und unausgeglichenen Grundlage liessen sich noch mancherlei Belege anführen für stoffliche und mechanische Vorstellungen bei geistigen Regelwidrigkeiten, wie z.B. die Beeinträchtigung des *sattva* bei Verletzungen des Herzens als einer Gefahrstelle (*marman*) in XIV, *479-80*, oder bei den alten Vorstellungen von einem Knoten

(*granthi*) im Herz nach XII, *8444*, *10998*, *12306*, seiner Verbindung mit Pflanzen, Fesslung, Gift (*9116 ff.*), den Fäden des Durstes oder der Begierde (*7877-8*) usw. Derartige Beispiele verleiten zur Annahme, dass Metaphern vorliegen, während regelmässig altüberlieferte Grundlagen bestehen, welche bei der Auswertung der tatsächlichen Anschauungen Berücksichtigung fordern. Aus diesem Gesichtswinkel heraus erscheint *sattva* spontan und ursprünglich gesondert gegen die pathologische Vereinigung von *rajas* und *tamas*, wie dies auch immer wieder die *Ātreya*-Tradition der Fachmedizin betont. Dort, wie auch im *MBh*, stehen die 3 *doṣa*s — Wind, Galle, Schleim — als Fehler des Körpers nicht den 3 *guṇa*s gegenüber oder korrespondieren mit ihnen. In XII, *7831* sind diese 3 *doṣa*s allein *rajas* und *tamas* gegenübergestellt, obwohl unmittelbar zuvor alle 3 *guṇa*s nebeneinander gereiht sind. Und diese Scheidung ist auch bei der Therapie durchgeführt; nach XII, *7462* und *12492* werden Krankheiten des Geistes durch Einsicht (*prajñā*), die des Leibes durch Kräuter (*oṣadhi*) geheilt.

Einsiedel. RHEINHOLD F. G. MÜLLER.

Arabische Übersetzer und Kommentatoren Euklids, sowie deren math.-naturwiss. Werke auf Grund des Ta'rīkh al-Ḥukamā' des Ibn al-Qifṭī

II*

IBN RĀHIWAIH AL-ARJĀNĪ (72).

Wie aus *Fihrist* 266 (17) hervorgeht, kommentierte dieser das zehnte Buch des *Euklid*. Über seine Persönlichkeit ist man vollständig im Unklaren. Nach dem Beinamen zu urteilen, stammt er aus der Stadt Arrajān (oder Arjān) in Fārs (Persis). Hierzu ist aber zu bemerken, dass diese Stadt nicht im Jahre 488 von dem Sāssanīdenkönig QAWĀDH I. gegründet wurde. Der Name Arjān wird sich wohl auf eine ältere Ortschaft beziehen (73).

I. al-Qiftī führt unter der Kunye AL-ARJĀNĪ zwei Autoren auf, nämlich ABŪ SA'ĪD AL-ARJĀNĪ (74), sowie ABŪ SAHLIN AL-ARJĀNĪ (75). Inwiefern wir aber diese beiden Ärzte (ṭabīb) zur Autorschaft heranziehen dürfen, kann nicht entschieden werden.

'ALĪ B. AḤMAD AL-ANṬĀKĪ ABŪ'L-QĀSIM (76).

I.al-Qiftī, 234_4 :

... der Auserwählte (al-mujtabā) der Antiochier, wählte Bagdad zum Wohnsitz, bis dass er daselbst starb. Er gehörte zu den Freunden des 'AḌUD AD-DAWLA, des Sohnes eines bekannten BŪYIDEN (77). Er beschäftigte sich mit der Rechenkunst ('ilm

* S. Isis, XX, 150-72.

(72) SUTER : *Araber*, 17, Art. 33.

(73) *Encycl. d. Islām*, I, 477.

(74) *I. al-Qiftī*, 408_1.

(75) *I. al-Qiftī*, 408_{10}.

(76) SUTER : *Araber*, 63; CANTOR, I_3, 761.

(77) Sein Vater war RUKN AD-DAWLA. 'AḌUD AD-DAWLA heisst mit dem voll-

al-'Adad) (78) und Geometrie (al-Handasa) mit Erfolg. Und er schrieb auf diesem Gebiet schöne Abhandlungen. Er nahm mit grossem Interesse an den Wissenschaften von den Anfängen ('Ulūm al-awā'il) Teil. Er war beredt und ausgezeichnet in der Rhetorik. Wenn er gefragt wurde, erklärte er und zwar mit schönem sprachlichen Ausdruck... Von ihm haben wir sehr schöne Bücher. 1) at-takht al-kabīr (Die grosse Tafel), über das indische Rechnen (al-ḥisāb al-hindī) (79).

2) Das Rechnen auf der Tafel ohne Auslöschen (80).

3) Kommentar zur Arithmetik (Arithmāṭiqī) (81).

4) Kommentar zum *Euklides*.

Dieser ist erhalten in Oxford, Ms. Bodley. bei Nicoll. n. 281.

5) Über die Auffindung (istikhrāj) der Übersetzer oder Übersetzungen (tarājim pl. von tarjuma Übersetzung, Biographie, Vorrede) (82).

6) Über arithmetische Proben (mīzān pl. mawāzīn, eigentl. Wage, Wagschale).

7) Über das Rechnen mit der Hand ohne Tafel (83).

Und es erwähnt HILĀL B. AL-MUḤSIN B. IBRAHĪM AṢ-ṢĀBĪ (84) in seinem Buch, dass ABŪ AL-QĀSIM 'ALĪ B. AḤMAD AL-ANṬĀKĪ AL-ḤĀSIB (der Rechner) AL-MUHANDIS (der Geometer) am Freitag, den 13. Dhu'l-Hijje d. J. 376 (987) gestorben sei.

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ständigen Namen 'AḌUD AD-DAWLA FANNĀ KHOSRAW ABŪ SHUJĀ B. RUKN AD-DAWLA. Lebenszeit 324 (936)—372 (983). *Encycl. d. Islām*, 1, 151.

(78) "Wissenschaft der Zahl". Häufiger tritt 'Ilm al-Ḥisāb als Rechenkunst auf: Die Rechenkunst gehörte zu den propädeutischen ('Ulūm riyāḍīya oder ta'līmīya) Wissenschaften, welche die vier Disziplinien (Quadrivium) Arithmetik, Geometrie, Astronomie und Musik umfassten. Vgl. E. W., B. XI. Über AL-FĀRĀBĪS Aufzählung der Wissenschaften. *Encycl. d. Islām*, 2, 334; E. W., B. XIV, Über die Geometrie und Arithmetik nach den Mafātiḥ al-'Ulūm, etc.

(79) Vgl. E. W., B. XIV, 19 Das indische Rechnen.

(80) Es wird sich hier wohl um das Rechnen auf der Staubtafel handeln.

(81) WOEPCKE: *Journal asiat.*, I, 6. Sér., 493 ff., 1863, vermutet des NIKOMACHUS (vgl. STEINSCHNEIDER: *Math.* § 136; I. AL-QIFṬĪ, 336, 13. NĪQŪMĀCHUS B. MĀKHĀ'UN AL-FĪTHĀGHŪRĪ a) (der Pythagoräer). Man versteht unter Arithmāṭiqī den theoret. Teil der Rechenkunst, welchem vor allem *Euklid* Buch VII-IX zugrunde liegt. E. W., B. XIV, 12 ff. B. XI, 87 ff.

(82) SUTER: *Übers.*, 75 Anm. 275.

(83) Die Araber hatten ausser dem schriftl. Rechnen auf Papier, Handtafel, etc. das sog. Fingerrechnen (Ḥisāb bi'l-Iṣābī; Ḥisāb al-'Uqūd), das Handrechnen (Ḥisāb al-Yad) und das Luftrechnen (Ḥisāb al-hawāīy). Es ist dies ein Kopfrechnen.

(84) BROCKELMANN, 1, 323.

NIKOMACHUS.

I.al-Qiftī, 336_{13} :

NIKOMACHUS, Sohn des MACHAON—MĀCHĀ' ŪN, war vermählt mit ANTIKLEA; dies sind die Eltern des Zwillingspaars NIKOMACHOS und GORGAS, welche die Heilkunst von ihrem Vater ererbten u. deswegen in Pharä göttliche Verehrung genossen — und Vater des ARISTOTELES, war ein Edler unter den Griechen und Enkel des ASKLEPIUS (Asqlabiyādhis), welcher die Medizin (aṭ-ṭibb) begründete; so erwähnt ihn PTOLEMÄUS, der Fremde (al-gharīb), in seinem Buche. Und er stammte aus einer griechischen Stadt, genannt Stagira, welche in einer griechischen Provinz, genannt Jihrashan, gelegen ist.

Und NIKOMACHUS war ein Pythagoräer (Fīthagūrī al-madhab) und studierte ihre Lehren. Es gab sogar Griechen, welche ihn nur als Pythagoräer kannten. Und er war Arzt (muṭabbib) eines gewissen PHILIPPONUS, des Vaters von ALEXANDER, und Schüler PLATONS (Aflāṭūn). Zu seinen Werken gehören :

1) Die Arithmetik (al-Aritmāthīqī fī 'ilm al-'Adad) (gr. *εἰσαγωγὴ ἀριθμητική*) zuerst hersg. von WECHEL, Paris, 1538, neueste Ausgabe von R. HOCHE, Leipzig, 1866; sie besteht aus zwei Büchern :

Buch 1 handelt nach einer kurzen philosophischen Einleitung über die Klassifikation der Zahlen, und zwar der Einteilung der geraden Zahlen in :

1) *ὑπερτελεῖς*

Beispiel : Zahl 42; deren Teiler sind 21, 14, 7, 6, 3, 2, 1.

Dann ist $21 + 14 + 7 + 6 + 3 + 2 + 1 > 42$.

2) *ἐλλιπεῖς*

Beispiel : Zahl 32, Teiler 16, 8, 4, 2, 1.

$16 + 8 + 4 + 2 + 1 < 32$.

Anm. Der besondere Fall, dass Gleichheit besteht zwischen der Summe der Teiler u. der zu untersuchenden Zahl, wird nicht behandelt.

Beispiel : 28, Teiler : 14, 7, 4, 2, 1.

$14 + 7 + 4 + 2 + 1 = 28$.

Daran schliesst sich eine Aufzählung von Zahlenverhältnissen.

Buch 2 enthält Sätze über Reihen, sowie eine Darstellung von Polygonalzahlen (*ἀριθμοὶ ἐπίπεδοι*) und der Körper (*στερεοί*), deren Klassifikation und Bildung.

Als zweite Abhandlung zählt I. AL-QIFTĪ *l.c.* das kitāb annagham "Buch der Melodie" (*ἐγχειρίδιον ἁρμονικῆς*) auf.

Nach anderen Quellen soll NIKOMACHUS auch der Autor eines Werkes *τὰ θεολογούμενα τῆς ἀριθμητικῆς* sein, welches sich mit der mystischen Bedeutung der erstern 10 Zahlen in zwei Büchern befasst (vgl. FR. AST., Leipzig, 1817, V. DE FALCO, Leipzig, 1922). (Zur Einleitung in die Arithmetik des NIKOMACHUS von IAMBLICHUS vgl. H. PISTELLI, Leipzig, 1894).

AḤMAD B. AL-ḤUSAIN AL-AHWAZĪ (85), AL KĀTIB.

SUTER hält diesen identisch mit dem Sohne des ABŪ AḤMAD AL-ḤUSAIN B. KARNĪB AL-KĀTIB (*Fihr.*, 263 (15)).

I.al-Qiftī, 169,5 :

AL-ḤUSAIN B. ISḤĀQ B. IBRAHĪM B. YAZĪD AL-KĀTIB; ABŪ AL-ḤASAN B. ABĪ AL-ḤUSAIN, ABŪ AḤMAD, bekannt als IBN KARNIB, gehörte zu den hervorragenden Gelehrten in Bagdad und hing der Lehre der Naturphilosophen an. Sein Bruder war ABŪ 'ALĀ (86), welcher sich mit der Geometrie befasste. Wir werden ihn an geeigneter Stelle erwähnen, so Gott es will, er ist erhaben ! Und was ABŪ AḤMAD AL-ḤUSAIN anbetrifft, so war er ganz hervorragend in den alten Naturwissenschaften. Und von ihm haben wir Werke darüber, wie : 1) Widerlegung das THĀBIT B. QURRA betreffend seine Negation der Notwendigkeit der Existenz von Ruhepunkten zwischen zwei entgegengesetzten Bewegungen. 2) Wie man mittels der Höhe erkennen kann, wieviel Stunden des Tages verflossen sind (vgl. hierzu *Fihrist*, 273,4).

Im weiteren möchte ich auf SUTER : *Araber*, 57, verweisen (87). Betr. seiner Beschäftigung mit *Euklid* sind zu erwähnen : 1) Ein Kommentar zur 10. Ausgabe des *Euklid* (Hier nur als AL-AHWĀZĪ erwähnt, welchen AHLWARDT unbegründet mit 'ABDALLAH B. HILĀL AL-AHWĀZĪ identifiziert, Berlin, 5923). 2) Leiden, 370; ebenfalls Kommentar zum 10. Buche von AL-AHWĀZĪ. 3) Paris, 2467,18° : Auszug aus dem Kommentar zum 10. Buche des *Euklid*.

(85) D. h. aus AL-AHWĀZ, vgl. *Encycl. d. Islām*, I, 220.

(86) ABŪ 'ALĀ B. KARNĪB. SUTER, 49.

(87) Es erwähnt übrigens *I. al-Qiftī*, 436, einen ABŪ YA'QŪB AL-AHWĀZĪ, einen berühmten Arzt. Es dürfte wohl kaum möglich sein, diesen als Autor heranzuziehen.

ISḤĀQ B. ḤUNAIN (88).

I.al-Qiftī, 80 :

ISḤĀQ B. ḤUNAIN B. ISḤĀQ ABŪ YA'QŪB B. ABĪ ZAID AL-'IBĀDĪ AN-NAṢRĀNĪ (der Christ), stand im Range seines Vaters betr. der Vorzüglichkeit und Genauigkeit der Übersetzung aus dem Griechischen und Syrischen. Er war beredt und überragte darin seinen Vater; er diente den Khalīfen und Vorgesetzten, denen sein Vater diente. In seinen letzten Tagen löste er das Dienstverhältnis zu AL-QĀSIM B. 'UBAIDALLĀH (89). Er stand mit ihm in vertrautem Verhältnis. Ihm teilte er seine Geheimnisse mit. Er starb am Rabī'I, des Jahres 298 (910). Er wurde von einer Lähmung betroffen, woran er starb. Und zu seinen Werken gehören ausser jenen, welche er aus alten Büchern übersetzte, eine Abhandlung über die Medikamente, (gewonnen aus) der Arzneipflanze; 2. كتاب كتاش الضق ; 3. Chronik der Ärzte.

Er übersetzte die Elemente des EUKLID, welche durch THĀBIT B. QURRA verbessert wurden (*I. al-Qiftī*, 64_4) (90). Vorhanden in : Oxford, I, 919 u. 958 (91).

Wie SUTER : *Araber*, 39, Anm. b. bemerkt, wurde das 14. u. 15. Buch der Elemente von QUSṬĀ B. LŪQĀ übersetzt.

THĀBIT B. QURRA (92).

Ibn al-Qiftī, 115 :

THĀBIT B. QURRA B. MERWĀN B. THĀBIT B. KARĀYĀ B. IBRAHĪM B. KĀRĀYĀ B. MĀRĪNŪS B. TĀLĀMĀNUS ABŪ'L-ḤASAN AL-ḤARRĀNĪ (93) AṢ-ṢABĪ (94) war ein Harrānier. Er begab sich nach

(88) SUTER : *Araber*, 39; BROCKELMANN, 1, 206 ; H. SUTER : *Encycl. des Islām*, 2, 569.

(89) Dieser war Vezīr des Khalīfen AL-MU'TAḌID.

(90) CANTOR, I_3, 703.

(91) Es scheint sich hier nur um die Revision des THĀBIT B. QURRA zu handeln, welche erhalten blieb.

(92) SUTER : *Araber*, 34; E. W., B. LXIV. Über THĀBIT B. QURRA, sein Leben und Wirken. Die hier gegebene Übersetzung aus I. AL-QIFTĪ kam mir erst nachträglich in die Hände. Hier führe ich meine eigene, welche unwesentlich von jener abweicht, an. BROCKELMANN, 1, 217. Vgl. auch E. W., B. XX, 64 : Biographie nach AL-BAIHAQI; E. W., B. XXVIII, worin die Biographie von AL-BAIHAQĪ nach YĀQŪB mitgeteilt wird ; *Encycl. d. Islām*, 1, 616-17 ; CANTOR, I_3, 703.

(93) D. h. aus Ḥarrān (assyr. kharrānu "Weg"). Auf die Drohung AL-MA'MŪN's i. J. 830, dass sie ausgerottet würden, wenn sie nicht den Islām bezw.

Bagdad und wählte sich dies als Wohnsitz. Die Philosophie war Sieger über ihn. Er lebte unter der Regierung des AL-MU'TAḌID. Er verfasste viele Bücher über die verschiedensten Zweige (fanūn) der Wissenschaft, so z. B. über die Logik (al-mantiq), die Rechenkunst (al-Ḥisāb), die Geometrie (al-hindasa), die Astrologie (at-tanjīm, griech. Uṣṭurnūmiyā; vgl. hierzu E.W., XLVII, 216) und Astronomie (Ilm al-hai'a, E, W., B. XLVII, 220) (95). Er verfasste eine wundervolle Einleitung (mudkhil, gewöhnlich aber madkhal) zum Buche von *Euklid*, desgleichen eine Einleitung in die Logik. Auch übersetzte er das Buch über die Arithmetik (96) und verfasste einen Auszug aus dem Buche Über die Art und Weise der Heilung (97), welches von früheren Gelehrten dieser Wissenschaft herrührt.

THĀBIT wurde im Jahre 221 (98) in Harrān geboren, woselbst er ein Wechsler war. MUḤ. B. MŪSĀ B. SHĀKIR, (99) wählte ihn, als er vom Lande Rūm zurückkehrte, zu seinem Freunde, da er auf seine Sprachkenntnis aufmerksam wurde. Und es wird erzählt, dass er bei MUḤ. B. MŪSĀ Aufnahme fand und in dessen Hause studierte, wodurch er ihm verpflichtet wurde. Und er machte ihn bekannt mit AL-MU'TAḌID und führte ihn in den Kreis der Astronomen ein. Er führte die Herrschaft der Ṣābier im Irāq ein und befestigte ihre Macht. Sie genossen hohes Ansehen und ragten durch ihr Wissen weit hervor. Und es erlangte THĀBIT B. QURRA dadurch bei AL-MU'TAḌID einen sehr

eine der erlaubten Religionen annähmen, erklärten sie sich als Ṣabier. *Encycl. d. Islām*, 2, 286.

(94) Der Ṣabier. Ihre Prinzipien sind nach einer Auffassung 5 an der Zahl (Gott, die Weltseele, die erste Materie (hayūla), der dahr (Schicksal), das Leere). Nach einer andern nur zwei, nämlich Licht u. Finsternis. Vgl. HORTEN : *Die Philosophie des Islām*, 110, 1924.

(95) Vgl. hierzu auch die Artikel über Astrologie u. Astronomie von C. A. NALLINO in *Encycl. d. Islām*, 1, 514-20 sowie *E. W.*, B. IX, 181 „Zu der Astronomie bei den Arabern"; B. XI, 90 (Die Wissenschaft von den Sternen, nach AL-FĀRĀBĪ), B. XXVII, 37.

(96) Wahrscheinlich die des NIKOMACHUS.

(97) Vermutlich handelt es sich hier um eine Abhandlung des GALENOS.

(98) Dasselbe Jahr gibt *Fihrist*, 272, 4 an. Es muss 211 heissen.

(99) Er war einer der BANŪ MŪSĀ. Vgl. SUTER : *Araber*, 20-21; BROCKELMANN, 1, 216; *Al-Qiftī*, 315 u. 441 (hierzu besonders E. W., B. VI, 6 ff.). Weitere Mitteilungen über sie : E. W., B. III. 261; IV, 393; 423,4; 424; B. X, 341; XII, 200, 225; XVII, 14 ff. XXXVI, 21 ; F. HAUSER : Kitāb al-ḥiyal der BANŪ MŪSĀ, Beiheft 1 zu den *Sitzungsberichten d. physik.-med. Societät*, Erlangen, 1922.

hohen Rang und eine ausgezeichnete Stellung. Er pflegte sich sogar zu jeder Zeit in seiner Gegenwart niederzulassen. Und dann unterhielt er sich lange mit ihm und scherzte mit ihm. Er näherte sich ihm auch ohne Vezīre und Vertraute.

Was die Titel der Schriften anbetrifft, die er verfasst hat, so fand ich einige Blätter in einer Handschrift des ABŪ ALĪ AL-MUḤSIN B. IBRAHĪM B. HILĀL AṢ-ṢĀBĪ (100), welche über eine Bemerkung betr. der Abstammung des ABŪ AL-ḤASAN THĀBIT B. QURRA B. MERWĀN handelt, sowie ein Verzeichnis dessen, was er auf Grund eines eingehenden Studiums an Büchern verfasst hat. So füge ich sie hinzu, da für ihr Vorhandensein das folgende Verzeichnis als ein Beweis hierfür gilt. Und Gott ist der, der Erfolg gibt!

Verzeichnis dessen, was ABŪ'L-ḤASAN THĀBIT B. QURRA AṢ-ṢĀBĪ AL-ḤARRĀNĪ verfasst, übersetzt und verbessert hat (101).

2) Werk über die Physik (as-Samā' aṭ-ṭabī'ī).

3) Über Cylinderschnitte und deren Fläche.

4) Über die Ursache, welche das Salzigsein des Wassers bewirkt.

6) Abhandlung darüber, dass zwei Gerade, die unter Winkeln, die [zusammen] kleiner als zwei Rechte sind [von einer Geraden ausgehen], sich auf der Seite schneiden, aus der sie austreten.

7) Eine ähnliche Abhandlung darüber.

8) Über die Auflösung der geometrischen Aufgaben.

9) Über das Viereck und dessen Seite.

10) Über das, was man auf dem Mond an Spuren der Verfinsterung (al-Kusūf) (102) und deren Zeichen sieht.

11) Über die Ursachen der Sonnen- und Mondfinsternis; er verfasste deren grössten Teil; da er starb, konnte er es nicht vollenden (103).

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(100) Vgl. BROCKELMANN.

(101) Ich führe hier nur die math.-naturw. Schriften in der Reihenfolge des *I. al-Qiftī* an (vgl. die Numerierung).

(102) Über Mondfinsternis, Beschaffenheit der Schatten, Bestimmung der Ortszeiten, zu denen dieselbe Mondfinsternis an verschiedenen Orten auftritt, sowie die Bestimmung der Grösse derselben mit Hilfe des Diopter von HIPPARCH (a). Vgl. E. WIEDEMANN in *Encycl. d. Islām*, 2, 1246-48.

(103) Nach Auffassung der Araber durch das Dazwischentreten eines Drachens zwischen Sonne und Mond, welcher an zwei entgegengesetzten Stellen der Him-

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(a) Zu HIPPARCH, vgl. STEINSCHNEIDER: *Math.* 134; SUTER: *Übers.*, 22 u. 54; E. W., B. III, 227; *I. al-Qiftī*, 69, 8 (Übers. E. W., B. III, 251); E. W., B. V, 454.

Es gehört zu den ausgezeichnetsten Werken. Die Leute unserer Zeiten wünschen lebhaft, dass es vollendet wäre, was ihnen aber nicht erfüllt wird.

12) Antworten auf das an ihn gerichtete Werk von AḤMAD B. AṬ-ṬAYYIB (104).

14) Zwei Antworten auf zwei ihm vorgelegte Werke von MUḤ. B. MŪSĀ B. SHĀKIR über die Zeit.

16) Abhandlung darüber, dass an einem [Wage]balken passend aufgehängte Gewichte sich gerade so verhalten, wie wenn sie als ein Gewicht auf dem ganzen [Wage]balken gleichmässig verteilt wären (105).

17) Über die Ausmessung (misaḥa) der ebenen (musaṭṭaha) Figuren und der übrigen Flächen (busuṭ) und körperlichen Figuren.

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melskugel endigt u. dieselbe Bewegung wie die Mondknoten hat. Dieses sind die Stellen, wo der Mond die Ekliptik passiert. Man bezeichnete den aufsteigenden Knoten mit "Kopf" und den absteigenden Knoten mit "Schwanz" des Drachen. Die Zeit zwischen zwei Durchgängen des Mondes durch den aufsteigenden Knoten nannte man "drakonitische Umlaufszeit".

Im aufsteigenden Knoten tritt der Mond von der Südseite der Ekliptik auf die Nordseite, umgekehrt beim absteigenden Knoten.

Der drakonitische Monat beträgt $27^d\ 5^h\ 5^m\ 36^s,0$. Der siderische Monat (= die volle Umlaufszeit des Mondes um die Erde) beträgt $27^d\ 7^h\ 43^m\ 11^s,55$.

Also: Drakonitischer Monat < siderischer Monat. Ursache: Rückläufige Bewegung der Knoten beim drakonitischen Monat.

(104) *I. al-Qiftī*, 77. SUTER: *Araber*, 33; hier muss es heissen *Fihrist* 261 (15). Es wird dies dasselbe Werk sein, welches der *Fihrist* u. *I. al-Qiftī*, ersterer unter dem Titel „Antworten des THĀBIT B. QURRA auf das, was von ihm erfragt wurde (!), erwähnt. Da sich AḤMAD B. MUḤ. B. MERWĀN B. AṬ-ṬAYYIB AS-SARAKHSĪ nur mit philosophischen, naturwissenschaftlichen, politischen Fragen befasste, so scheint der Inhalt obiger Schrift ein derartiges Thema zu behandeln.

(105) Es handelt sich hier jedenfalls um die Sätze: Wenn das Gewicht K gleichmässig und in gleicher Weise und kontinuierlich ausgebreitet ist in dem Bereich zwischen *a* und *b*, so bleibt der Balken (wie vorher) im Gleichgeweiht; bezhw. um den Satz: Ein homogener Zylinder von durchaus gleichmässiger Gestalt und Materie, der seiner Länge nach an einem Arme eines gewichtlosen Hebels befestigt ist, kann in seiner Wirkung auf die Drehung des Hebels ersetzt werden durch ein gleichschweres Gewicht, welches an seinem Mittelpunkte angreift. Dieser letzte Satz wurde von THĀBIT B. QURRA in seiner Schrift über den Qarastūn bewiesen, welchen Beweis F. BUCHNER in den *Sitzungsberichten der physik.-med. Societät* zu Erlangen, Bd. 52 u. 53, 1920-21) S. 160, mitteilt.

Zu dem Begriff Gewicht ist noch zu bemerken, dass er von dem der Masse nicht unterschieden wurde. Daher kommt es, dass bei ihm die Kraft f = G. v (G = Gewicht, v = Geschwindigkeitsvektor) ist, welches Produkt wir Impulsvektor nennen.

18) Über die Natur der Gestirne (kawākib pl. v. kaukab) und deren Einfluss (106).

21) Über die Ursache der Entstehung der Berge.

22) Sur la retardation du mouvement dans la sphère des signes et sur son accélération suivant les points de l'excentrique où se trouve le (corps en) mouvement (107).

23) Drei Bücher zur Erklärung des Almagests. Eines derselben, nämlich das grösste und beste, blieb unvollendet (108).

24) Über die befreundeten Zahlen (109).

25) Über Stundeninstrumente, genannt Rukhāma (110).

26) Über die Konstruktion des Körpers von 14 (?) Flächen in eine gegebene Kugel.

27) Erklärung der Art und Weise, wie nach Angabe des PTOLEMÄUS seine Vorgänger die mittlere Umlaufszeit des Mondes bestimmt haben.

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(106) Vgl. E. W., B. LXIV, 213.

(107) Vgl. *Fihrist:* Übers., 77. Es handelt sich hier um die Hypothese von der Trepidation der Fixsterne des THABIT B. QURRA. Sie wurde aufgestellt zum Zwecke der Übereinstimmung der Beobachtungen der Griechen mit denen der Araber betr. der Schiefe der Ekliptik und der Präzession. Im Gegensatz zu den Griechen war ihnen eine langsame, fortlaufende Abnahme der Schiefe der Ekliptik schon bewusst; vgl. O. SCHIRMER: Studien zur Astronomie des Araber, *S. B. P. M. S.*, Erlangen, 58-59, 33-43, 1926-27. Anm.: Die Schiefe der Ekliptik, d. h. die Deklination der Sonne in den Solstitialpunkten, wodurch die Neigung der Ebene der Ekliptik gegen die des Äquators gemessen wird, hat für das Jahr 1900 nach Newcomb einen Wert von 23° 27' 8.26". Ihre Abnahme betrug im Jahrhundert 46" 845. Die Präzession besteht darin, dass der Pol des Äquators in einer Periode von 26000 Jahren um den Pol der Ekliptik einen Kreis mit $r = 23° 27'$ beschreibt. Ihre Veränderung ist eine Folge des Newtonischen Gravitationsgesetzes.

(108) STEINSCHNEIDER, *Z. D. M. G.*, 50, 202-03.

(109) Für die Primzahlen $p = 3 \cdot 2^n - 1$, $q = q \cdot 2^{n-1} - 1$, $r = 9 \cdot 2^{2n-1} - 1$ sind 2^n p. q; 2^n *p.r* befreundete Zahlen. Es ist dies eine Weiterentwicklung der arithmetischen Untersuchungen des NIKOMACHUS u. der Behandlung der vollkommenen Zahlen des EUKLID. (Prop. 36 in Buch IX: Irgend eine Summe der Reihe $1 + 2 + 2^2 + 2^3 + \ldots 2^n$ sei eine Primzahl. Multipliziert man dann dieselbe mit der letzten der in der Reihe stehenden Zahlen, so erhält man eine vollkommene Zahl, welche gleich der Summe iher Teiler ist. Z. B. $(1 + 2 + 4 + 8 + 16).16 = 496$.

$496 = 248 + 124 + 62 + 31 + 16 + 8 + 4 + 2 + 1$) Vgl. CANTOR, I_3, 268 u. 735.

(110) Rukhām pl. rukhāma „Marmor". Es sind dies Sonnenuhren, welche aus Marmorplatten bestehen, vgl. AL-BATTĀNI, ed. E. NALLINO, 1, 135. (vollst. Titel: *al-Battānī sive Albatenii opus astronomicum*, 3 Bde., Mailand, 1899-1907).

28) Über die Eigenschaften des Gleichgewichtes u. Nichtgleichgewichtes und deren Bedingungen.

29) Über die Fragen, die ABŪ' L-ḤASAN 'ALĪ B. YAḤYĀ, der Astronom, aus der Musik stellte.

30) Auszug aus den zwei Büchern der Arithmetik des NIKOMACHUS.

31) Maqāla über die Musik.

32) Sätze über die sinnreichen Anordnungen (al-hiyal) (111).

33) Auszug aus dem ersten Buche des Quadripartitums des PTOLEMÄUS.

35) Antworten auf die an ihn gerichteten Fragen des ABŪ SAHL AN-NAUBAKHTĪ (112).

36) Über Kegelschnitte (113).

37) Über die Ausmessung parabolischer Körper (114).

39) Über das Sonnenjahr.

40) Über die Erscheinung der Neumonde im Süden.

41) Über die [Zeit]-Rechnung nach Neumonden.

42) Über die Kugel.

46) Über den Unterschied der Länge (115).

47) Über die Beschaffenheit der [Kegelschnitts]-Kurven, welche der Schatten des miqyās passiert (116).

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(111) Ḥiyal pl. von ḥila. Die Übersetzung mit Mechanik ist nicht ganz exakt (E. W., III, 233), X, 347; XI, 80,1; XIV, 61, etc.).

(112) Vgl. E. W., B. LXIV, 217.

(113) Es handelt sich hier um die Bücher V, VI, u. VII, welche nur in arabisch. Übersetzung existieren, also in griechischen nicht mehr vorhanden sind. Das VIII. Buch ging jedenfalls verloren.

(114) H. SUTER : Die Abhandlungen THĀBIT B. QURRA's u. ABŪ SAHL AL-KŪHĪ's über die Ausmessung der Paraboloide. (*Sitzungsb. d. phys.-med. Societät* zu Erlangen, 48-49, 186-227).

(115) Vielleicht handelt es sich hier um die Länge von Örtern. Die Länge eines Ortes wurde von den Arabern als Abstand desselben von Osten (d. h. dem äussersten bewohnten Ort in den östlichen Gebieten) oder von Westen (d. h. dem aüssersten bewohnten Ort in den westlichen Gebieten) gerechnet u. zwar nach den Mafātih al-'Ulum. Vgl. eingehender E. W., B. XXVII, 9 u. 38.

(116) Die Bezeichnung miqyās „Messer" rührt daher, weil er vom Fuss bis zur Spitze in eine Anzahl Teile geteilt war, in denen man die Länge seines Schlagschattens mass.

Ist die Anzahl der Teile des miqyās 12, so heissen sie Finger (a).

Ist die Anzahl der Teile des miqyās 60, so heissen sie Teile.

Ist die Anzahl der Teile des miqyās 6½, so heissen sie Füsse.

Es sei f = Anzahl der Finger; φ die der Füsse, ρ die der Teile, dann ist $f\,\frac{1}{2}\frac{3}{4}=\varphi$. $f.\,\frac{6}{1}\frac{0}{2}=p$; $\varphi\,\frac{2}{1}\frac{4}{3}=f$, $\varphi\,\frac{1}{1}\frac{2}{3}\frac{0}{0}=p$, $p.\,\frac{1}{1}\frac{3}{2}\frac{}{0}=\varphi$, $p.\,\frac{1}{0}\frac{7}{0}=f$.

48) Über die Transversalenfigur (117).

49) Über die Geometrie, welche er verfasste für Ismā'īl b. Bulbul (118).

53) Auszug aus dem Buche über die Klimate, das Wasser u. die Länder (119).

55) Über die Breiten ('urūḍ pl. von 'arḍ) (120).

57) Über die Kugel.

59) Über die erste Darstellung (?) einer Analytik.

63) Über die Verfügung über Mass (Regel) formen.

64) Über das, was THEON (THĀ'ŪN) (121) vernachlässigt hat bei der Berechnung der Sonnen- und Mondfinsternisse.

65) Über die Berechnung der Sonnen- u. Mondfinsternisse.

66) Über die Nau (122).

69) Über al-'adad al-wafq (die magischen Zahlen). Vgl. CANTOR, I_3, 740-41; E. W., B. LXIV, 213_2. Lit: E. WIEDEMANN: Zu den magischen Qadraten (*Der Islām*, 8, 1918). W. AHRENS: Studien über die mag. Quadr. der Araber (*Der Islām*, 7, 186, 1917). G. BERGSTRÄSSER: Zu den mag. Quadr. (*Der Islām*, 12, 227, 1923). W. AHRENS: Nochmals die magischen Quadrate, (*der Islām*, 14, 1925). Encyclopädie des Islām, etc.

Vgl. C. SCHOY: Über den Gnomonschatten, etc., Hannover, 1923. E. W., B. XVIII, 50.

(117) v. BRAUNMÜHL: *Geschichte d. Trigonometrie*, I, 46. THĀBIT behandelte darin auch den Satz des MENELAOS.

Zu MENELAOS vgl. *Fihrist*, 267 (19); *I. Al-Qiftī*, 321 (Übers. E. W., B. III, 253); E. W., B. V, 395; VI, 11; XV, 107 ff.; etc. Vor allem aber: A. A. BJÖRNBO's Studien über MENELAUS Sphärik (*Abh. z. Gesch. d. Math.*, H. 14, Leipzig, 1902).

(118) E. W., B. LXIV, 194, Anm. 17.

(119) Vielleicht ist es auch ein Auszug aus dem gleichnamigen Werk des AḤMAD B. AṬ-ṬAYYIB AS-SARAKHSĪ? Vgl. E. W., LXIV, 215, wo auf ein Werk des HIPPOKRATES (von HIPPOKRATES wurde auch ein Werk über die Farben ins Arabische übersetzt. H. Ch., 5, 50 nach I. A. Uṣ.) hingewiesen wird.

(120) 'arḍ „geographische Breite", welche durch die Polhöhe bezw. Depression des Südpols definiert wird. Unter der Breite der Fixsterne versteht man den senkrechten Abstand von der Ekliptik. (Vgl. auch E. W., B. XXVII, 9 u. 38).

(121) Zu THEON vgl. *Fihrist*, 268 (21); *I. Al-Qiftī*, 108 (Übers. E. W., B. III, 254); STEINSCHNEIDER: *Math.* § 128; T. LIPPERT: *Studien auf dem Gebiete der griech.-arab. Überlieferung*, H. 1, Braunschweig, 1794.

(122) Vielleicht handelt es sich hier um die heliakischen Auf- u. Untergänge der Mondstationen? Vgl. zu dem Begriff nau: E. W., B. XLVII, 215.

(a) Diese Einteilung geht auf indische Vorbilder zurück (Sūrya-Siddhānta, Cap. 3, Vers. 2. Ediert v. E. BURGESS (*Journal of the American Oriental Society*, 6, 1860).

72) Über den Gebrauch der „erprobten" Tafeln und Darstellung dessen, was er an ḤABASH in diesen seinen Tafeln auszusetzen hatte (123).

73) Über die Ausmessung des Schnittes der Linien (124).

74) Über das Flöteninstrument.

76) Eine Anzahl von Schriften über arabische und syrische astronomische Beobachtungen.

81) Über die Verifikation algebraischer Aufgaben durch geometrische Beweise.

83) Verbesserung des 1. Buches des APOLLONIUS über das bestimmte Verhältnis; er gab eine sehr gute Rezension mit Kommentar dazu; das zweite Buch behandelte er nicht, es war unverständlich (125).

84) THĀBIT verbesserte eine Übersetzung des Almagests ins Arabische von ISḤĀQ B. ḤUNAIN; es verlangten danach die daran Interessierten bzhw. Freunde des ISḤĀQ. Darauf verfasste er eine ausgezeichnete Übersetzung, welche er verbesserte und erläuterte; und wir besitzen ein Autograph. Hierauf verfasste er (THĀBIT) einen nützlichen Auszug aus dem Almagest; den 13. Traktat kürzte er nicht; es ist nämlich der beste. Und ich fragte einen unserer Mashāichs nach der Ursache desselben, worauf er sagte, es ist vollständig. Auch hatte er den I. u. II. Traktat dieses Buches kommentiert, und einige unserer Zeitgenossen benützten die [Erläuterungen] und folgten ihm (darin) (126).

85) Er verbesserte den *Euklid* in zwei Abhandlungen, welche er auch ins Arabische übersetzte, von welchen die zweite besser als die erste ist.

86) Er kommentierte das 14. u. 15. Buch, was in einer Handschrift des AL-MUḤSIN B. IBRAHĪM AṢ-ṢĀBĪ mitgeteilt wird.

87) Eine Anzahl Kompendien über Astronomie u. Geometrie.

88) Antworten über die zwei Teile von 200 auf eine Frage von AL-MU'TAḌID.

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(123) Vgl. hierzu SUTER: *Araber*, 8, 12; in diesem Artikel gibt SUTER auch die Übersetzung aus *I. Al-Qifṭī*, 170.

(124) Es wird sich hier wohl um die Ausmessung der Kegelschnitte handeln.

(125) CANTOR, I_3, 749.

(126) STEINSCHNEIDER: *Math.* § 113, 203..

90) Über die Ursache der Abweichung der Tafeln (zīj) (127) des PTOLEMÄUS von den "erprobten" Tafeln.

91) Anworten auf eine Anzahl ihm von SANAD B. 'ALĪ vorgelegten Fragen.

93) Auszug aus PYTHAGORAS (?) und... (128)

Auf die nun folgenden Schriften, die unser Interesse infolge ihres medizinischen, bezhw. religiösen Inhaltes nicht beanspruchen, verzichte ich in der Aufzählung (129).

I.al-Qiftī, 120_{22} :

Es berichtet ABŪ'-L-ḤASAN B. SINĀN : Einer meiner Vorfahren erzählte von unserem Ahnen THĀBIT B. QURRA, dass er, als er eines Tages in das Haus des Chalifen ging, ein Schreien und Jammern hörte. Da sagte er : "Es starb der Fleischer, welcher in dieser Bude wohnte". Da sagten die Leute zu ihm : "Ja, bei Gott, o unser Herr ! Er ist gestern plötzlich gestorben". Da sagte er : "Er ist nicht gestorben. Bringt mich zu ihm !" Darauf gingen die Leute mit ihm und brachten ihn in das Haus des Fleischers. Alsdann ermahnte er die Weiber, sich des Klagens zu enthalten und befahl ihnen, eine muzawwara (Speisegericht aus Hülsefrüchten) herzustellen. Und er gab einem seiner Sklaven ein Zeichen, damit er dem Fleischer auf seinen Fussknöchel mit einem Stock schlage und seine Hand an seinen Puls lege. Alsdann schlug jener solange seinen Fussknöchel, bis dass er sagte : "Genug !" Darauf verlangte er einen Becher u. nahm aus einem Bündel (130) unter seinem Ärmel eine Arzenei, welche er mit ein wenig Wasser in dem Becher auflöste. Da öffnete er den Mund des Fleischers und goss sie hinein. Darauf schluckte dieser sie leicht. Und siehe da ! — Ein lauter Jubel erhob sich

(127) Definition von zīj nach den Mafātiḥ al-'Ulūm ist folgende : al-zij (Sterntafeln) ist ein Werk, mittels dessen man den Gang der Gestirne und durch das man die Ephemeriden (taqwīm) ermittelt, nämlich die Lage der Wandelsterne Jahr für Jahr feststellt. Vgl. E. W., B. XLVII, 223-24.

(128) QITĀGHURIYĀS. Wenn dieser Name PYTHAGORAS gelesen werden darf, was sehr wahrscheinlich ist, so möchte ich hier eine Abhandlung über vollkommene Zahlen vermuten.

(129) Zu den übrigen math.-naturw. Arbeiten verweise ich auf die Bibliographie in SUTER : *Araber*, 35-38, sowie *E. W.*, B. LXIV, 210-17 u. F. BUCHNER : Die Schrift über den Qarastūn von THĀBIT B. QURRA, *Sitzungsberichte* 52 u. 53, 141, 1920-21.

(130) Ich lese hier shabka „Bündel". Dieses Wort tritt verstümmelt auf.

auf der Strasse ! "Der Arzt hatte den Totgeglaubten (!) am Leben erhalten !" Hernach trat THĀBIT hervor u. verschloss die Türe. Nun öffnete der Fleischer sein Auge, worauf er ihm die muzawwara gab und ihn sitzen liess. Und er verweilte bei ihm eine Weile. Und siehe da ! Die Freunde des Chalifen kamen zu ihm, um ihn zu rufen. Da trat er mit ihnen heraus. Während dessen hatte sich eine grosse Menge angesammelt, welche sich um ihn drängte, bis dass er in das Haus des Chalifen eintrat. Und als er vor dem Chalifen stand, sagte dieser zu ihm : "O THĀBIT, was für eine Botschaft ist dies, welche uns von dir erreichte ?" Er sagte : "O mein Herr ! Ich ging an diesem Fleischer vorbei und bemerkte, wie er die Leber (aus einem Tiere) herauschnitt u. Salz darauf streute und selbiges ass. Zunächst widerte mich sein Tun an. Darauf nahm ich an, dass ihn eine Apoplexie treffen würde, und ich begann hierauf, ihn zu beobachten. Ich entfernte mich und setzte eine Arznei gegen die Apoplexie zusammen, welche ich stets mit mir trug. Als ich heute vorbeikam, hörte ich ein Geschrei. Ich sagte : "Der Fleischer ist gestorben". Sie sagten : "Ja, er ist gestern plötzlich gestorben". Da wusste ich, dass es die Apoplexie war, welche ihn befallen hatte, und ich trat zu ihm ein. Er hatte keinen geregelten Pulsschlag. Da liess ich seine Fussknöchel solange schlagen, bis dass sich der [geregelte] Pulschlag anzeigte. Darauf flösste ich ihm die Arznei ein, worauf er sein Auge öffnete. Dann gab ich ihm die muzawwara [zu] essen. Des Nachts ass er feines Brot mit Haselhuhn. Am folgenden Tag ging er heraus aus seinem Haus."

THĀBIT B. QURRA, der Grossvater des THĀBIT B. SINĀN, des Verfassers einer Chronik (SUTER: *Araber*, 59), starb am Donnerstag dem 26. Ṣafar i. J. 288 d. H. (900).

Und es preist ihn ABŪ AḤMAD YAḤYĀ B. 'ALĪ B. YAḤYĀ AL-MUNAJJIM AN-NADĪM, zwischen welchen beiden eine Freundschaft bestand, mit folgenden Versen (vgl. E. W., LXIV, 199).

JĀBIR B. ḤAYYĀN (131) :

Zunächst gebe ich dessen Biographie aus *I. Al-Qifti* S. 160 (132):

(131) SUTER : *Araber*, S. 3 ; CARRA DE VAUX in *Encyclop. d. Islām*, 2, 1029. BROCKELMANN, I, 240 f.

(132) Vgl. auch die Lebensbeschreibung unseres Autors von AIDAMIR AL-JILDAKĪ († 1342 oder 1361, BROCKELMANN, II, 138) in seinem Kitāb al-burhān fī asrār 'ilm al-mīzān (Beweis über die Geheimnisse der Wissenschaft der Wage), deren dritter Teil einen Kommentar zu dem Werk des JĀBIR B. ḤAYYĀN über

JĀBIR B. ḤAYYĀN AṢ-ṢŪFĪ (133) AL-KŪFĪ (134) war berühmt in den Naturwissenschaften ('ulūm aṭ-ṭabī' iyya) und ragte darin besonders in dem Zweige der Alchemie (135) hervor. Von ihm stammen darüber viele ausgezeichnete Werke. Er befasste sich ausserdem mit vielen philosophischen Wissenschaften und hing der 'ilm al-bāṭin (136), d.h. der Lehre der Ṣūfīs, an, wie AL-ḤĀRITH B. ASD AL-MUHĀSIBĪ (137) und SAHL B. ABDALLAH AT-TUSTARĪ (138) und andere. Und es berichtet MUḤHAMMAD B. SA'ĪD AS-SARAQUSṬI (aus Saragossa) (139), bekannt unter dem Namen IBN AL-MASSĀT (Sohn des Friseurs) AL-AṢTURLĀBĪ (d-h. Hersteller von Astrolabien) AL-ANDALUSĪ, dass er in Kairo ein Werk über den Gebrauch des Astrolabiums von JĀBIR B. ḤAYYĀN gesehen habe, welches tausend Probleme enthielt, dem nichts gleichkam — Gott weiss es am besten!

Zu seinem Leben möchte ich folgendes noch bemerken. Wie wir aus dem *Fihrist* entnehmen können, bestanden schon zu Lebzeiten des IBN AN-NADĪM, des Verfassers des Quellenwerkes, verschiedene Meinungen über unsern Autor. Die verschiedenen

die sieben Körper enthält. Dieselbe teilt J. RUSKA nach HOLMYARDS Übersetzung in „*Der Islām*", XVI, H. 3/4, S. 264 (JĀBIR IBN ḤAYYĀN und seine Beziehungen zum Imam JA' FAR AṢ-ṢADIQ) mit.

(133) Er hing der Lehre des Ṣufismus an, deren Vertreter weltentsagende Büsser u. Asketen des Islāms sind. Sie kleiden sich gerne in grobwollene Kleider (ṣūf), was wohl zur Benamung Ṣūfī Anlass gab. Vgl. I. GOLDZIEHER, *Vorlesungen über den Islam*, 1910, S. 139-58 Anm., 186-200).

(134) aus Kufa?

(135) Al-Kīmiyā, sie wird sonst nach ṣan'at al-Kīmiyā', ṣan'at al-iksīr (a), ilm aṣ-Ṣinā'a etc. bezeichnet. Das arabische Wort geht durch Vermittlung des Syrischen auf *χημεία*, die griechische Benennung für Alchemie, zurück.

(136) Unter bāṭin versteht man den inneren Sinn, in welchem die Wahrheit enthalten ist. Diese durch den Ẓāhir verhüllte Wahrheit wird entsprechend der Vorbereitung offenbar. Zu den bāṭiniyya gehören sowohl die Ismā'iliten, als auch die Ṣūfīs.

(137) Gest. in Bagdad, 214/857; BROCKELMANN, I, 198.

(138) Gest. 273 oder 283 (886 oder 896); BROCKELMANN, I, 190.

(139) SUTER: *Araber*, 104, 215, *50.

(a) Iksīr ist synonym mit Kīmiyā, worunter eine Substanz zu verstehen ist, mit Hilfe derer die Metallverwandlung bewirkt wird. E. WIEDEMANN in *Encycl. des Islām*, II, 1085-93 (Behandelt werden: 1. Name; 2. Alchemisten u. deren Schriften; 3. Theoretische Anschauungen derselben. 4. Alchemistische Schwindler; 5. Wege zur Lösung des alchemistischen Problems; 6. Benützte Substanzen; 7. Benützte Vorrichtungen; 8. Benützte Verfahren; 9. Synthetische u. analyt. Methoden; 10. Technische Verfahren. Daran schliesst sich eine weitgehende Literaturübersicht an.

Beinamen können uns nur einen groben Hinweis zur Orientierung über ihn geben. So besagen AL-KŪFĪ, dass er aus Kufa stammte; AL-AZDI (auch AL-ASD) (140), dass er zum Stamme Azd gehörte. Die vereinzelt auftretende Kunye AṬ-ṬŪSĪ bezhw. AṬ-ṬARṬŪSĪ weist darauf hin, dass er ein Abkömmling einer Familie aus Ṭūs (141) war.

Wie es nun um die Verbindung zwischen JĀBIR B. ḤAYYĀN und dem Imām Ja'FAR AṢ-ṢĀDIQ steht, ist nur schwer zu beantworten. Es ist dies eine Frage, worauf vor allen Dingen J. RUSKA in Alchemisten, II, 41-52; *Der Islām*, XVI, 264-66, E. J. HOLMYARD : An Essay on JĀBIR IBN ḤAYYĀN. Studien zur Geschichte der Chemie, Festgabe zur EDMUND O. v. LIPPMANN, hrsg. von J. RUSKA, 28-37, J. SPRINGER, Berlin, 1927, und andere schon erwähnte Werke eine bis jetzt nur unbefriedigende Antwort zu geben vermögen.

Das Todesjahr unseres Autors scheint auf Grund der ausgezeichneten Forschungen von J. RUSKA u. E. J. HOLMYARD (JĀBIR IBN ḤAYYĀN, *Proc. of the Roy. Soc. of Medicine*, 16, 46 ff., 1923) um das Jahr 870, sein Geburtsjahr um 730-750 zu liegen.

Auf Grund dieser Feststellungen ist die Angabe in H. Ch., dass JĀBIR 776 oder 777 gest. sei, sowie die Annahme, er sei ein Schüler HĀLID IBN YAZĪD's (gest. 704) gewesen, hinfällig.

Ich erwähnte diesen JĀBIR nur deshalb, weil er der Verfasser eines Kommentars zu *Euklid* sein soll, welche Frage sich aber bis heute noch nicht beantworten liess (142).

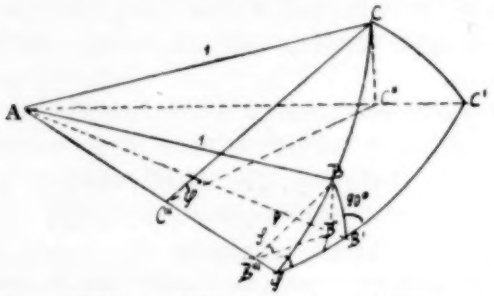
JĀBIR BEN AFLAḤ (143) :

I.al-Q. S. 319 u. 339 erwähnt nur seine Astronomie, welche in den Handschriften verschiedentlich als „kitāb al-hai'a" und "Iṣlāh al-majisṭī " (Verbesserung des Almagest) aufgeführt wird. JĀBIR darf wohl mit diesem astronomischen Werk mit MASLAMA AL-MAJRĪṬĪ (144) (gest. 398), IBN AS-SAMH (145) (gest. 426) und AL-ZARQĀLI (146) zu den bedeutendsten spanischen Astronomen

(140) *Encycl. d. Islām*, I, 550-51.
(141) J. RUSKA : *Alchemisten*, II, 10 Anm. 4.
(142) Vgl. J. RUSKA, *Alch.*, II, 48.
(143) *Encycl. d. Islām*, I, 1029; v. BRAUNMÜHL, I, 81 ff.; SUTER : *Araber*, 119; CANTOR, I_3, 794-96; F. NOLTE : Die Armillarsphäre (Dhāt al-ḥalaq) 7; 21. (*A. G. N. M.*, Erlangen, H. 11).
(144) *I-Al-Qiftī* S. 326 (Übers. SUTER : *Araber*, 76).
(145) SUTER : *Araber*, 85.
(146) *I-Al-Qiftī*, 58 (Übers. SUTER : *Araber*, 109).

gezählt werden. In seiner Astronomie bekämpft er besonders PTOLEMÄUS in der Behauptung, es gäbe "kein Mittel, zu beweisen, welches die wahre Stellung der Planeten sei, *dass keine derselben eine merkliche Parallaxe* zeige, die das einzige Mittel zur Bestimmung der Distanz geben würde". Um die Planeten mit beschränkter Elongation von den übrigen abzuscheiden, setzte er Merkur und Venus zwischen Mond und Sonne (147). Von besonderer Bedeutung wurde der nach ihm benannte "Satz des Geber", welchen ich kurz entwickeln möchte (148).

An die Spitze seiner Betrachtungen stellt er die "Regula quatuor quantitatum", welche sich folgendermassen ergibt.

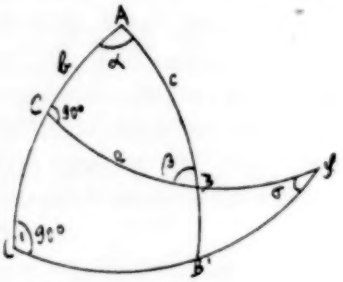


I) sin BB′ = BB″ = BB‴ sin S = sin SB. sin S.

II) sin CC′ = CC″ = CC‴ sin S = sin SC. sin S.

sin SB : sin SC = sin BB′ : sin CC′ (Regel der vier Grössen) (149).

(Oder sin SB : sin BB′ = sin SC : sin CC′).



(147) R. WOLF: *Handbuch d. Astronomie*, I, 491.

(148) Er findet sich in dem Kapitel über sphärische Trigonometrie, welches zusammen mit einer Abhandlung über ebene Trigonometrie (Sehnentrigonometrie) seinem astronomischen Werke vorausgeschickt wird.

(149) Anders geschrieben $\frac{crd\ 2SB}{crd\ 2SC} = \frac{crd\ 2BB'}{crd\ 2CC'}$

crd = chorda. — Vgl. auch BRAUNMÜHL., I, 17.

Wir wenden nun unsere Regel von den vier Grössen auf obenstehende Figur an.

Da C = 90° = C′, so ist S der Pol von CC′, also $\hat{S}C = 90°$

sin SB : sin BB′ = sin SC : sin CC′

sin (90° — *a*) : sin (90° — *c*) = sin 90° : sin (90° — *b*).

Woraus die schon den arabischen Vorgängern des IBN AFLAḤ, sowie PTOLEMÄUS bekannte Relation cos *c* = cos *a* cos *b* folgt. Auf ähnliche Weise erhält man alsdann den Satz des GEBER : cos *α* = cos *a* sin *β* (150).

Betr. des Verdienstes von JĀBIR um *Euklid* ist auf eine Handschrift in Berlin 747 Qu zu verweisen, welche Erklärungen in hebräischer Übersetzung enthält.

'ALĪ B. MUḤ. AS-SAYYID ASH-SHARĪF AL-JURJĀNĪ (151) (740/1339-816/1413).

An math.-naturw. Werken sind von ihm zu erwähnen :

1) Kommentar zu den Mulachchaṣ fī'l-hai'a (Kompendium der Astronomie) des MAḤMŪD B.-MUḤ. B. 'UMAR AL-JAGHMĪNĪ 152).

2) Kommentar zur tadḏkīra (Erinnerung) über die Astronomie des NAṢĪR AD-DĪN AṬ-ṬŪSĪ.

3) Glossen zu Ṭūsī's Redaktion (taḥrīr) des *Euklid*.

AL-'ABBĀS B. SA'ĪD AL-JAUHARĪ (153) :

I.al-Qiftī, 219.

AL-'ABBĀS B. SA'ĪD AL-JAUHARĪ, der Astronom (al-munajjim), war erfahren in der Kunst des tasyîr (154) und der Astronomie

(150) CANTOR, I_3, 795-96.

(151) Zu seinem Leben u. seinen Werken vgl. C. BROCKELMANN in *Encycl. d. Islām*, 1, 1113, sowie SUTER : *Araber*, 172 (C. BROCKELMANN: *Gesch. d. ar. Lit.*, II, 216).

(152) Dieses Werk des JAGHMĪNĪ erfuhr eine deutsche Übersetzung durch RUDLOFF u. HOCHHEIM in *Z. D. M. G.*, 47, S. 213 ff.; vgl. H. SUTER, in *Encycl. d. Islām*, 1, 1038; SUTER : *Araber*, 164.

(153) SUTER : *Araber*, 12.

(154) tasyîr, directio, ἄφεσις. Man versteht darunter die Vorausberechnung des von dem Planeten zurückzulegenden Weges.

Z. B. Ermittlung des tasyîr nach PTOLEMÄUS :

Man ermittelt den Abstand *a* des Sternes S, von dem man bei der Einteilung ausgeht, vom Meridian und die Dauer *t* einer Tagstunde des Sternes R, dessen tasyîr man machen will. Die Zeit multipliziert man mit obigem Abstande *a* und teilt das Produkt *a.t.* durch die Dauer T einer Tagstunde des Sternes S. Zieht man von diesem Quotienten noch den Abstand *b* des Sternes R vom Meridian ab, so findet man die gesuchte Einteilung. Also *a.t* — *b* = tasyîr (directio) (vgl.

(Ḥisāb al-Falak) (155), Vorgesetzter in der Handhabung der Beobachtungsinstrumente (ālāt al-arṣād) und ein Freund AL-MA'MŪN's. Und dieser berief ihn zur Unternehmung der Beobachtung zur Zahl derer, die hierzu bestellt waren, bei[m Tor] Shamāsīya in Bagdad. Und er stellte die Orte einiger Planeten (al-kawâkib as-sayyâra) (156) und der beiden Leuchten (nayyirānī) (157) fest. Er verfertigte hierzu eine berühmte, bei den Männern seines Faches bekannte Sterntafel (158). Er und seine Begleiter SANAD B. 'ALI, KHĀLID B. 'ABDALMALIK AL-MARWARRŪDHĪ (159) und YAḤYĀ B. ABĪ MANṢŪR (160) waren die ersten, welche in der islāmischen Gemeinde astronomische Beobachtungen anstellten. Darauf taten es andere ihm nach auf diesem Gebiet

C. A. NALLINO, *Al-Battāni*, I, 313 ff.; F. NOLTE : Die Armillarsphäre, *A. G. N. M.*, Erlangen, Heft. II, 46, 1922). Es dürfte vielleicht auch von Interesse sein, die Definition des tasyîr nach den Mafâtîḥ al-'Ulûm hier anzuführen.

„At-tasyîr besteht darin, dass man sieht, wieviel zwischen dem Hailâg (Es gibt deren fünf : Sonne, Mond, der ṭāli', d. h. das im Osten aufgehende Tierkreiszeichen, der sahm as-sa'āda (a), der Teil des Ijtimā' (Konjunktion) oder des Istiqbāl (Opposition)), der zwischen dem Glück oder dem Unglück liegt. Man nimmt für jeden Grad ein Jahr und sagt : das Glück oder das Elend trifft ihn auf so und soviel Jahre.

(155) Ḥisāb al-Falak : Berechnung der Himmelssphäre, d. h. die theoretische Astronomie (von AVERROES u. AL-FĀRĀBĪ : ṣinā'at an-nujûm at-ta'līmīya = die auf die Sterne bezügliche mathematische Kunst bezeichnet).

(156) Es sind dies Saturn (zuḥal), Jupiter (albirjīs), Mars (mirrīkh), Sonne (shams), Venus (zuhara), Merkur ('uṭārid) und Mond (qamar). Ihre persischen Namen sind : Kaiwān, Hurmuz, Bahrām, Khwār, Nāhid, Tîr, und Mah. Die Fixsterne werden im Arabischen „al-kawâkib at-thābita" d. h. die feststehenden Sterne, genannt.

(157) Nämlich Sonne und Mond.

(158) al-Zīj ist die arabische Form des Persischen zih „Sehne". Mittels der Sterntafeln ermittelt man den Gang der Gestirne, sowie die Ephemeriden (taqwīm).

Wir erhalten die Konstruktion einer Ephemeride, indem wir aus den Tafeln der Wandelsterne, welche die Beziehungen, die zwischen den Koordinaten und der Zeit eines Wandelsterns bestehen, enthalten, für eine gewisse Zeitfolge deren Koordinaten berechnen u. zweckmässig zusammenstellen.

(159) SUTER : *Araber*, 11 (20).

(160) Zu YAḤYA B. ABĪ MANṢŪR, ABŪ ALĪ, vgl. SUTER : *Araber*, 8 ; *I. al-Qifti*, 357-59 (Übers. bringe ich weiter unten.).

(a) Sahm as-Sa'āda „Pfeil des Glückes" ist nach AL-BĪRŪNĪ „der Ort auf dem Tierkreis, der von dem ṭāli' in der Aufeinanderfolge der Tierkreiszeichen ebenso weit absteht wie der Mond von der Sonne entsprechend den aufeinanderfolgenden Zeichen. Vgl. E. W. : „Über die Astronomie nach den Mafâtîḥ al-'Ulûm", B. XLVII, „Zu der Astronomie bei den Arabern" B. IX; " Geographische Stellen aus den Mafâtîḥ", B. XXVII, 37-40. *Encycl. d. Islām*, 1, 515.

entsprechend dem, was noch folgen wird über die Mitteilungen der einzelnen von ihnen. Er hat darüber Werke verfasst.

1. Das Werk [über] die Tafeln;

2. Kommentar (tafsīr) zum Buche des EUKLID.

3. Buch der Sätze (ashkāl), welche er zur ersten maqāle des EUKLID [hinzugefügt hat]. Anm.: Über das Vorhandensein dieser Werke liess sich bis jetzt noch nichts ermitteln.

YAḤYĀ B. ABĪ MANṢUR.

I.al-Qiftī, 357-59 :

YAḤYĀ B. ABĪ MANṢUR, der Astronom unter AL-MA'MŪN, war ausgezeichnet in diesem Zweig, von grossem Ansehen dazumal und fester Stellung. Er stand in Verbindung mit AL-MA'MŪN, dem Herrscher der Gläubigen. Er trat bei ihm hervor in der beobachtenden Astronomie und dem tasyīr der Sterne. Und als AL-MA'MŪN sich zur Beobachtung der Sterne entschloss, trat er vor YAḤYĀ. Und in einer Versammlung [der Astronomen] (161) wurden deren genaue Namen notiert. Er beauftragte sie mit der Beobachtung und der Verbesserung der Beobachtungstafeln. Darauf führten sie die aus in Shammāsiyye in Bagdad und am Gebirgsstock Qāsiyūn (162) in Damaskus. Dies geschah in den Jahren 215, 216, und 217 (163). Mit dem Tode AL-MA'MŪN's im Jahre 218 wurden die Beobachtungen abgebrochen. YAḤYĀ B. ABĪ MANṢŪR starb im Lande Rūm (164). Er verfasste : "Die erprobten Tafeln", in zwei Handschriften; Die Bestimmung der Höhe des Sechstels einer Stunde für die Breite von Bagdad (165).

Es erzählte ABŪ MA'SHAR (166) : "Es berichtete mir MUḤ.

(161) So ist diese Stelle wohl zu verstehen. Es handelt sich hier um die Namenfeststellung der bei der Beobachtung anwesenden Personen.

(162) Qāsiyūn ist ein über 1200 m. hoher Gebirgsstock, welcher die Vorstadt Ṣāliḥīya von Damaskus beherrscht.

(163) Die Beobachtungen in Bagdad hatten zur Aufgabe, systematisch die Bewegungen der Himmelskörper zu untersuchen, sowie die Prüfung der grundlegenden Angaben des Al-magest. Auf Grund dieser Untersuchungen entstanden die zīj al-mumtaḥan, „erprobten Tafeln".

(164) Er wurde in Ḥalab (Aleppo) begraben.

(165) *I. al-Qiftī* hat : ذ العمل لسذس ساعة ق
الارتفاع مدينة السلام

(166) Es ist die JA'FAR B. MUḤ. B. 'Umar Abū MA'SHAR AL-BALKHĪ. SUTER : *Araber*, 28. *I. al-Qiftī*, 152.

B. MŪSĀ, der Astronom, der Gesellschafter (al-jalīs) und es ist nicht AL-KHWĀRIZMĪ (167); es teilte mir YAḤYĀ B. ABI MANṢUR [folgendes] mit : "Ich trat ein bei AL-MA'MŪN, während bei ihm eine Versammlung der Astronomen stattfand, sowie ein Mann zugegen war, welcher für sich die Prophetenschaft in Anspruch nahm. Da liess AL-MA'MŪN für ihn Stöcke kommen [um ihn zu traktieren], und [siehe da], sie waren nicht mehr da und wir wissen nichts [davon] (168). Darauf sagte AL-MA'MŪN zu mir und den anwesenden Astronomen : "Geht weg und nehmt das tāli' (169) zur Begründung eines Mannes in einer Sache, welche er für sich in Auspruch nimmt und teilt mir mit, was auf ihn hinweist der Himmelskreis (falak) betr. seiner Wahrhaftigkeit und Lügenhaftigkeit". Und AL-MA'MŪN teilte uns nicht mit, dass er für sich die Prophetenschaft beanspruchte. Darauf gingen wir zu einem der Höfe, beurteilten das tāli' und stellten in einer Minute den Ort der Sonne u. den des Mondes, sowie den Pfeil der Glücks (sahm as-sa'āda) (170), den Pfeil des Verborgenen (sahm al-ghaib) (171) u. das tāli' fest. Und das tāli' war der Steinbock. Der Jupiter (al-mushtarī) in der Ähre (sunbula) stand ihm gegenüber. Und Venus u. Merkur im Skorpion ('aqrab) standen ihm

(167) Diese Stelle weist mit besonderem Nachdruck auf die öfters vorkommende Verwechslung mit MUḤ. AL-KHWĀRIZMĪ (SUTER : *Araber*, 10, *I.al-Q.*, 286) hin; vgl. auch *I.al-Q.*, 284/16: „MUḤ. B. MŪSĀ, der Astronom, der Gesellschafter — und es ist nicht AL-KHWĀRIZMĪ, — war gelehrt in der Astronomie u. zeigte sich erfahren in den Zusammenkünften der Könige u. deren Versammlungen. Er lebte zur Zeit AL-MA'MŪN's u. nachher".

Zu dem Leben u. Wirken der BANŪ MŪSĀ, vgl. besonders F. HAUSER : Über das kitāb al-hiyal (das Werk über die sinnreichen Anordnungen) der BANŪ MŪSĀ, *A. G. N. M.*, Heft 1, Erlangen, 1922.

(168) Diese Stelle muss ich fraglich hinstellen, zumal im folgenden auch nicht mehr darauf hingewiesen wird.

(169) Does tāli' (ascendens), oft einfach mit Horoskop zu übersetzen. Es ist das im Osten aufgehende Tierkreiszeichen (der aufgehende Punkt der Ekliptik). Über die Ermittlung des tāli' mit dem Astrolabium u. der Armillarsphäre siehe : F. NOLTE: Die Armillarsphäre, *A. G. N. M.*, H. 2, 47, Erlangen; J. FRANK : Die Verwendung des Astrolabs nach AL-KHWĀRIZMĪ, ebenda H. 3, 6; C. SCHOY : 'ALĪ IBN 'ISĀ, das Astrolab u. sein Gebrauch, *Isis*, 9, 242, 1927; J. FRANK u. M. MEYERHOF : *Ein Astrolab aus dem indischen Mogulreiche*, 22, (Heidelberg, 1925).

(170) Sahm pl. Sihām (partes, Lose) sind im Grunde genommen fingierte Ascendenten. Sie werden auf der Ekliptik in einem gewissen Abstand vom wahren aufgehenden Punkte gezählt.

(171) Sahm al-ghaib ist der Pfeil, der beim Aufgang des Krebes untergeht.

gegenüber. Da sagte jeder der Anwesenden : "Was er für sich in Auspruch nimmt, ist berechtigt !" Und ich schweige ! Da sagte AL-M'AMŪN zu mir : "Was sagst du ?" Da sagte ich : "Seine Rechtfertigung ist gesucht, da er einen Beweis in der Venus u. im Merkur hat. Und der Beweis dessen, was er für sich beansprucht, ist unvollkommen und nicht in Ordnung." Da sagte er zu mir : "Auf Grund wessen behauptest du das ?" Ich sagte : "Deswegen, weil die Richtigkeit des Anspruches nach dem Jupiter, sowie dem Trigonalschein (tathlīth) (172) und dem Sextilschein (tasdīs) der Sonne beurteilt wurde (173). So war die Sonne glücklich. Und dieses tāli' widerspricht ihm deshalb, weil es die Dejektion (hubûṭ) (174) des Jupiters ist. Und der Jupiter

(172) Beim Sextilschein beträgt die Längendifferenz der betr. Planeten (in unserem Falle „Sonne" u. „Jupiter") 60°. Beim Trigonalschein beträgt sie 120°. Diese beiden Begriffe bilden mit denen der Opposition (Istiqbāl, maqābala, Gegenschein : Beide Planeten stehen sich diametral gegenüber) u. der Quadratur (Quadratschein, tarbī', Längendifferenz der beiden Planeten 90°) die vier Aspekte. Hier ist noch der Begriff al-Ijtimā' (Konjunktion) zu erwähnen. Es handelt sich hierbei nur um die Stellung von Sonne u. Mond zueinander. Nach den Mafātiḥ al-'Ulûm (E. W. B. XLVII, 238) bedeutet al-Ijtīmā' das gänzliche Schwinden (muḥâq) des Mondes (Neumond) ; denn der Mond vergesellschaftet sich in dieser Zeit mit der Sonne.

Dagegen bedeutet Oirān oder Muqārana insbesondere die Konjunktion von Saturn und Jupiter.

(173) Trigonal- u. Sextilschein gelten in der Astrologie als günstig, dagegen als ungünstig der Geviertschein.

(174) Ein Planet befindet sich in seiner Dejektion, wenn er in einem Tierkreiszeichen steht, wo er die geringste Wirkung ausübt. (*de Slane*, 20, 219, Anm., 7) Vgl. MAFĀṬIḤ AL-'ULŪM (E. W., B. XLVII, 234) :

„Al-Hubûṭ steht dem Sharaf (a) gegenüber" (d. h. um 180° ab).

(a) Sharaf (altitudo, Dignität) ist ein bestimmter Grad in einem Tierkreiszeichen, das dem betr. Planeten zugeteilt ist. Die Erhöhungen der Sterne sind für Sonne 19° im Widder, Mond 3° im Stier. Saturn 21° in der Wage, Jupiter 15° im Krebs, Mars 28° im Steinbock, Venus 27° in den Fischen, Merkur 15° in der Jungfrau; vgl. E. W. *ib.* 238-39.

Planeten	Erhöhungen	Erniedrigungen
☉	♈ 19°	♎ 19°
☽	♉ 3°	♏ 3°
♄	♎ 21°	♈ 21°
♃	♋ 15°	♑ 15°
♂	♑ 28°	♋ 28°
♀	♓ 27°	♍ 27°
☿	♍ 15°	♓ 15°

steht ihm günstig gegenüber, ausgenommen dann, wenn er dieses Tierkreiszeichen und das Tierkreiszeichen ihn hasst.

Somit sind Beweis und Begründung unvollendet. Und das, was er als Beweis, gestützt auf Merkur u. Venus, anführte, so ist es eine Art von Vermutung u. Verschönerung und man betrügt sich gerne damit". Da sagte AL-MA'MŪN zu mir : "Was für ein trefflicher Mensch bist du !" Hierauf sagte er [weiter] : "Wisst ihr von dem Manne?" Wir sagten : "Nein". Er sagte : "Dieser beansprucht für sich die Prophetenschaft." Da sagte ich : " O Amīr Al-Mu' minīna (Beherrscher der Gläubigen)! Hat er etwas bei sich, womit er es beweisen kann?" Da fragte er ihn, worauf er antwortete : "Ja, ich habe einen Ring bei mir mit zwei Steinen; den legte ich an. Jedoch, es ergab sich nichts mit ihm, womit etwas hätte bewiesen werden können. Und es legte ein anderer als ich ihn an. Da lachte er und hörte solange nicht auf damit, bis dass er ihn ablegte. Und ich besitze [auch] ein syrisches Schreibrohr, welches ich nahm, um damit zu schreiben. Und als ein anderer als ich es nahm, da konnte er nicht damit schreiben". Da sagte ich : „O mein Herr ! Diese Venus und dieser Merkur haben ihre Arbeit ausgeführt". Da befahl ihm AL-MA'MŪN, und er führte aus, was er [AL-MA'MŪN] von ihm verlangte. Darauf sagten wir : „Dies ist eine Art Talisman !" Und AL-MA'MŪN hörte damit viele Tage nicht auf, bis dass er gestand und Verzicht leistete auf den Anspruch der Prophetenschaft. Und er beschrieb die List, welche dem Siegel und dem Schreibrohr zueigen war. Da liess AL-MA'MŪN ihm 1000 Dīnār schenken. Darauf sahen wir ihn später noch einmal. Und siehe, er gehört zu den gelehrtesten in der Wissenschaft der Beobachtung ('ilm aṭ-tanjūn) u. den grössten Freunden 'ABDALLAH B. AS-SURĪ's. ABŪ MA'SHAR erzählte : "Er ist derjenige, welcher Talismane herstellt gegen den Steinkäfer (khunāfis), der in vielen Häusern von Bagdād anzutreffen ist". Weiter sagte ABŪ MA'SHAR : "Wäre ich an Stelle [jener] Leute gewesen, so hätte ich Dinge geäussert, die gegen sie gerichtet gewesen wären (?)". Ich hätte gesagt : „Der Anspruch ist falsch deshalb, weil das Tierkreiszeichen verkehrt ist. Und der Jupiter ist im wabāl (Schaden) (175), der Mond im muhāq (176), und die beiden gegenüberliegenden Sterne

(175) Vgl. E. W. B. XLVII, 234.
(176) D. h. das gänzliche Verschwinden des Mondes : Neumond.

in einem lügnerischen Tierkreiszeichen, nämlich dem Skorpion.

MUḤ. B. YŪSUF B. AḤMAD B. MU'ĀDH AL-JUHANĪ, ABŪ-'ABDALLĀH (177).

Ob er der Verfasser eines Kommentars zum 5. Buche des *Euklid* (Algier 1446, 3°) ist, ist noch nicht endgültig entschieden (178).

AL-ḤASAN B. 'UBAIDALLĀH B. SULAIMĀN B. WAHB, ABŪ MUḤ (179).

I. al-Qiftī, 164 :

AL-ḤASAN B. UBAIDALLAH B. SULAIMĀN B. WAHB entstammte dem berühmten Hause der Herrschaft (180). Er war ausgezeichnet in der Geometrie, in welchem Zweig er produktiv tätig war (?) Er schrieb : Kommentar zu den schwierigen Partieen (sharḥ al-mushkil) des Euklidischen Buches über das Verhältnis (fī'l-nisbe) in eine Maqāle (181).

ABŪ JA'FAR AL-KHĀZIN (182).

I.al-Qiftī, 396 :

Mit seinem Beinamen (AL-KHĀZIN) bekannter als unter seinem [eigentlichen] Namen, war der Abstammung nach Perser. Er war sehr erfahren in Arithmetik und Geometrie, sowie im tasyīr,

(177) Vgl. SUTER : *Araber*, 96 (213). Die Kunye AL-JUHANĪ lässt auf eine gewisse Verwandtschaft mit AL-JUHAINA (a), einem zu der grossen südarabischen Gruppe der Quḍā'a gehörigen Stamme schliessen.

(178) Hier steht anstatt Al-JUHANĪ der Beiname AL-JAIYĀNĪ. Sollte unser Autor ev. der Abstammung nach aus Qumasrīn, welches oft geradezu als Jaiyān bezeichnet wurde, sein?

(179) SUTER : *Araber*, 48.

(180) Er war der Sohn von 'UBAIDALLĀH B. SOLAIMĀN B. WAHB, dem Wazīr des Khalifen AL-MU'TAḌID.

(181) Vgl. *Fihr.* Übers., 60 (139), sowie SUTER : *Araber*, 211 (23).

(182) SUTER : *Araber*, 58. Nicht zu verwechseln mit ḤAKĪM ABŪ'L-FATḤ 'ABD AR-RAḤMĀN AL-KHĀZIN, dem Verfasser des Kitāb Mīzān al-Ḥikma (Buch von der Wage der Weisheit), sowie Al-Zīj al-mu'tabar as-sinjarī (die geschätzten Sinjarischen Tafeln; sie enthalten Angaben von Fixsternörtern für 509 d. H., sowie für schiefe Ascensionen u. Zeitglchgn. für die Breite von Merw). Ausführliche Literaturangaben bei E. W. in *Encycl. d. Islām*, II, 1006.

(a) Hierzu vgl. C. H. BECKER in *Encycl. d. Islām*, I, 1107 (Derselbe : *Der Islām*, I, 155 ff).

der [astronomischen] Beobachtung und Anwendung derselben (183). Er war bekannt in diesem Zweig zu seiner Zeit. Er schrieb :

1. Das Tafelwerk der Scheiben; es ist dies das schönste und erhabenste Werk auf diesem Gebiet (184).

2. Buch über die Zahlenprobleme.

Bei SUTER nicht erwähnt ist ein Werk über die wunderbaren Beobachtungsinstrumente (H. Ch., V, 48, Nr. 9887) (185).

Über einen Beweis zur Fundamentalgleichung cos c = cos a cos b unseres Autors, von NAṢĪR AD-DĪN AṬ-ṬŪSĪ mitgeteilt, vgl. BRAUNMÜHL, I, 67.

Auch befasste sich AL-KHĀZIN mit der Auflösung kubischer Gleichungen, welche er auf geometrischem Wege mittelst Kegelschnitte versuchte (186).

Zu seinem Kommentar zum Eingang des Xten Tractates des EUKLID verweise ich auf G. JACOB u. E. WIEDEMANN : Zu Omer-i Chayyām, *der Islām*, III, 56, 1912.

Von AL-BĪRŪNĪ wird von ihm noch ein Werk mit dem Titel

(183) D. h. wohl Verwertung für die Astrologie.

(184) Es handelt sich hier wohl um die Scheiben (ṣafīha pl. ṣafā'iḥ) des Astrolabiums (*ὁ ἀστρολάβος, ὁ ἀστρόλαβος*, al-aṣṭurlāb).

Über die etymologische Besprechung des Namens al-Aṣṭurlāb (Aṣṭar „Stern„ Lābūn „Anblick" oder satār Bāb „Sterntor" etc.) vgl. E. WIEDEMANN, B. XVIII, 33; E. W., B. LVII, 29.

Die Astrolabien lassen sich auf 3. Grundtypen zurückführen :

1. Astrolabium planisphaerium (das flache „saṭḥī" oder „musaṭṭaḥ" Astrolabium). Bei diesem Instrument wird die Himmelskugel auf eine Ebene projiziert.

2. Linearastrolabium (Khaṭṭī), welches auch der Stab des Ṭūsī ('aṣa'ṭ-Ṭūsī) genannt wird. Dieser Typ stellt die Projektion der Himmelskugel auf eine gerade Linie dar.

3. Das sphärische Astrolabium (al-kurī). Dies veranschaulicht die tägliche Bewegung einer Himmelskugel, bezogen auf den Horizont eines gegebenen Ortes, ohne Projektion. Literaturangaben über das Astrolab befinden sich bei J. FRANK u. M. MEYERHOF : *Ein Astrolab aus dem indischen Mogulreiche* (Heidelberg, 1925).

(185) Vgl. E. W., B. IX, 190... Ein Werk über die Beobachtungen existiert von IBN AL-HAITHĀM, das die Theorie dieses Gebietes umfasst, und eines über die wunderbaren Instrumente von AL-KHĀZINĪ, das deren Anwendung behandelt. Siehe besonders F. NOLTE : Die Armillarsphäre, *A. G. N. M.*, H. II, 18.

(186) CANTOR, I_3, 774.

"Zeichnung des Horizontes der Aufgänge für die Tierkreiszeichen" angeführt (187).

'Umar b. Ibrahīm al-Khayyāmī, Abū l-Fatḥ (188).

I.al-Qiftī, 243 :

'Umar al-Khayyām, der Imām (189) von Khorāsān (190) und der grösste Gelehrte der Zeit, war in den Wissenschaften der Griechen bewandert. Er wurde dazu getrieben, den Einzigen, den Weltenrichter zu suchen durch die Läuterungen (taṭhīr) der körperlichen Regungen, um die menschliche Seele von allem Irdischen freizumachen. Auch ordnete er an, dass man die Verpflichtung des Musterstaats (as-Siyāse al-madaniye) nach griechischen Normen auf sich nehmen solle. Die Sūfī der späteren Zeiten blieben bei etwas von dem offenkundigen Sinn seiner Poesie stehen und übertrugen ihn dann in ihre Ordensregel und disputierten und meditierten darüber. Ihr verborgener Sinn aber sind Schlangen, welche die göttlichen Vorschriften stechen, sind Sammelplätze, die den geheimen Hass aufspeichern. Da die Leute seiner Zeit seinen Glauben angriffen und das, was er davon verbergen wollte, klarlegten, da fürchtete er für sein Leben und legte seiner Zunge und seinem Schreibrohr Zügel an (191). Er machte die Pilgerfahrt aus Menschen- nicht aus Gottesfurcht. Er offenbarte Geheimnisse der mystischen Vereinigung mit Gott ohne Worte. Als er nach Bagdad kam, eilten die Leute seiner Richtung in der alten Wissenschaft zu ihm. Er aber verschloss seine Tür für sie, als ein Bereuender nicht als ein Vertrauter. Nachdem er von seiner Pilgerfahrt in seine Heimat zurückgekehrt war, begab er sich abends und morgens zu der Andachtsstätte. Seine Geheimnisse verbarg er, sie wurden aber doch offenbar.

(187) E. W., B. LX, 84.

(188) Vgl. G. Jacob u. E. Wiedemann : *Zu 'Umer-i-Khayyām* ; Cantor, I_3, 774 ff.; R. Wolf : *Handbuch der Astronomie*, I, 608; Suter : *Araber*, 112; E. Ross : *Journ. Roy. Asiatic Society*, 349, 1898 ; V. Schukowski in der Festschrift al-Muẓaffarīye für Baron v. Rosen. *Iranischer Grundriss*, II, 316-57.

(189) Imām. Führer, Vorbild, Urbild.

(190) Khorāsān, im Osten des Irān gelegen, wird das Land „der aufgehenden Sonne" bezeichnet. (Khūr „Sonne", āsān aufgehend).

(191) Al-Khayyām glaubte an die Seelenwanderung.

In der Astronomie und Philosophie hatte er nicht seinesgleichen. Man hätte ihn als Muster in diesen Gebieten aufgestellt, wenn er von Gott den unschuldigen Sinn erhalten hätte.

Von ihm rührt eine elegante Poesie her, deren geheimer Sinn durch die ihn verhüllenden Ausdrücke hindurch scheint, deren Gedanken aber die Unreinheit ihres verborgenen Sinnes trübt.

Von ihm stammt folgendes Gedicht :

1. Wenn mein Seele sich zufrieden gibt mit Leichterreichbarem, das durch Anstrengung meine Handfläche und mein Arm erlangt,

2. Bin ich vor allen Wechseln der Ereignisse geborgen. So drohe mir, o meiner Zeit, oder fördere mich.

3. Haben nicht etwa die Himmelssphären in ihrer Drehung beschlossen, dass sie alles Glück in Unglück wenden?

4. So habe also Geduld meine Seele an dem Ort deiner Mittagsruhe, ihre Gipfel neigen sich nur, weil die Fundamente baufällig sind, zur Erde".

Schriften werden von ihm an dieser Stelle keine angeführt. Aus anderen Quellen (vgl. angef. Lit.) wissen wir, dass er der Verfasser folgender Werke ist.

1) Abhandlung über die Beweise zu den Problemen der Algebra (192).

2) Über die Kunst, die Quantitäten des Goldes und des Silbers in einem aus diesen beiden Metellen gemischten Körper zu erkennen (193).

3) Über die allgemeine (muṭlaq) Wasserwage; sowie deren

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(192) Vgl. F. Wöpcke : L'algèbre d'Omar al-Khayyāmī, Paris, 1851.

(193) Vgl. E. W., B. VI, 11; B. VIII, 170. Betrachtungen zu 'Umar al-Khayyāmī über die Bestimmung des Gehaltes von Legierungen zweier Metalle an denselben (Gotha, cod. arab., 1158, 110). 'Umar al-Khayyāmī stützt sich bei der Lösung des Problems im wesentlichen auf das Verhältnis des Gewichtes der Körper in Luft u. Wasser, wobei er die in Betracht kommenden Grössen graphisch als Linien aufträgt. Es ist das fünfte Bāb (Kapitel) der 4ten Maqāla (des 4ten Buches) aus dem Werke der Wage der Weisheit von al-Khāzinī. Dieses 5te Bāb behandelt in Faṣl (Paragraph) 1. die Herstellung der Wage und das Wägen mit ihr. In Faṣl 2 wird die unter Anm. 2 angeführte Aufgabe behandelt. Faṣl 3 befasst sich mit der Bestimmung des Gehaltes einer Legierung aus Gold und Silber mittels Gleichungen. (al-Jabr und al-Muqābala; zu diesem Begriff vgl. auch E. W., B., XVIII „Bestimmung der Durchmesser der um und in regelmässige Vielecke beschriebenen Kreise und des Inhaltes von Flächen und Körpern, sowie Stücke einer Lehre al-Jabr wa'l-Muqābāla"). Faṣl 4 Über die aus drei und mehr Substanzen zusammengesetzten Dinge.

Anwendung u. die sie betreffenden Beweise, wenn beide Schalen oder eine derselben im Wasser ist (194). Als vierte Abhandlung wäre nun noch sein Kommentar zu den schwierigen Stellen in den Postulaten (muṣādarāt) des EUKLID zu erwähnen, welcher vorhanden ist in Cod. Leid. Gol. Nr. 967. Hierzu verweise ich auf die oben zitierte Arbeit von G. JACOB u. E. WIEDEMANN, 53-59.

SA'ĪD B. YA'QŪB AD-DIMISHQĪ (195).

I.al-Qiftī, 409 :

ABŪ 'UTHMĀN AD-DIMISHQĪ, IBN YA'QŪB, aus Damaskus, war ein ausgezeichneter Schriftsteller. Er war mit 'ALĪ B. 'ISA intim befreundet. Er schrieb eine Abhandlung über die Medizin.

I.al-Qiftī, 64_5 : ... auch übersetzte ABŪ 'UTHMĀN einige Traktate desselben (des EUKLID). Ich sah *(I. al-Qiftī)* den Xten in Mossul, in der Bibliothek des 'ALĪ B. AḤMAD AL-'IMRĀNĪ, etc.

Es handelt sich hier um den Kommentar des PAPPUS zum Xten Buche des EUKLIDES. Wie ist nun die Autorschaft des PAPPUS zu rechtfertigen? F. WOEPCKE (196) schrieb diesen Kommentar VETTIUS VALENS, welcher ein Astronom zur Zeit des PTOLEMÄUS war, zu.

Ich will nun den Artikel von IBN AL-QIFTĪ über PAPPUS jenem über VALENS gegenüberstellen, um hieraus einen Schluss zu ziehen.

I. al-Qiftī, 99_{16} : B. N. S., aus dem Lande Rūm, war gelehrt in den mathematischen Wissenschaften, erfahren in den Schwierigkeiten der Geometrie. Er wohnte in Alexandria und lebte später als CLAUDIUS PTOLEMÄUS. Er verfasste : Kommentar zum Planisphärium (tasṭīḥ al-Kura) des PTOLEMÄUS, welches von THĀBIT B. QURRA ins Arabische übersetzt wurde. Kommentar zum Xten Traktat des Buches von EUKLID, 2 Maqālen.

Hierzu ist auch die Stelle aus *I. al-Qiftī*, $65_{7,\ 8}$ zu vergleichen, wo I.AL-QIFTĪ erwähnt : „Und ich sah einen Kommentar des

(194) Vgl. E. W., B. XV, 113.

(195) SUTER : *Araber*, 49; STEINSCHNEIDER, *Z. D. M. G.*, L., 405-06.

(196) F. WOEPCKE : *Mémoires prés. par div. sav. à l'académie des sciences*, 14, 658-720, Paris, 1856 (Enthält eine Inhaltsangabe dieses arabischen Manuskripts, sowie Übersetzung einiger Abschnitte).

Xten Traktates, welcher von einem alten Griechen, dessen Name B. līs ist, herrührt".

Hier führt LIPPERT Namensformen T. L. B. S. und A. B. Līn. S aus andern Manuskripten an.

I.al-Qiftī, 261 :

FĀLĪS AL-MIṢRĪ (der Ägypter), meistens WĀLĪS AR-RŪMĪ (der Romäer, Grieche) genannt, war ein hervorragender Gelehrter in der alten Zeit. Er war in den mathematischen Wissenschaften und den Judizien aus den Gestirnen (Astrologie) führend. Er verfasste darüber schöne, umfassende, der Gattung nach zweckmässige Werke. Er ist der Verfasser des unter den Gelehrten dieser Kunst berühmten Werkes, welches das Buch Al-Barīdj (197) AR-RŪMĪ genannt wird. BUZURJMIHR kommentierte es. Er verfasste auch eine Abhandlung über die Horoskope und was ihnen als Einleitung in die Wissenschaft von den Judizien der Gestirne vorhergeht. Und es berichtet Aydughur über ihn in seinem Werk [von] der Abhandlung über die Geburten, dass seine zehn Bücher über die Horoskope einen Band in der Stärke der übrigen Bücher bilden. Ausser den Abhandlungen, welche wir erwähnten, verfasste er noch : Das grosse Buch der Fragen jeder Art. Das Buch As-Sulṭān (198). Über den Regen (amtār). Über den Umlauf (tahwīl) der Jahre der Welt (199).

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(197) *Fihrist* hat hier Al-Zabraj (?). Möglicherweise handelt es sich hier um einen astrologischen Begriff. Der Konsonantenbestand ist in *I.al-Qiftī* nicht wesentlich von dem im *Fihrist* verschieden ; *Fihrist :* Z. B. R. G.; *Qiftī :* Z. B. R. J. Arabisch *d* und *z* können beim Abschreiben leicht ineinander verstümmelt werden. Vgl. hierzu auch SUTER : Übers., 21 sowie S. 65 (Anm. 188).

Möglich wäre allenthalben, dass es sich hier um AL-ZĀ'IJA handelt welches bei DE SLANE, Bd. 19, 245 u. Bd. 21, 199 Zā'iraja heisst (auch bei H. Ch., 3, 570).

AL-ZĀ'IJA ist die Form in den Mafātiḥ al-'Ulūm und wird definiert als eine viereckige oder runde Abbildung, die für die Orte der Sterne am Himmel hergestellt ist; man betrachtet sie bei der Feststellung der Nativität (maulid) oder ähnlichem. Das Wort kommt vom Persischen Zâyisch, d. h. Geburt; dann wurde es arabisiert und bei der Nativität oder ähnlichem verwendet (E. W., B. XLVII, 124).

(198) Sulṭān kann folgende Bedeutungen haben : Kaiser, Fürst, Macht, Herrschaft, Beweis, Befugnis. Welche Lesung die richtige ist, kann nicht ohne weiteres festgestellt werden. Da aber *Fihrist* noch ein Werk „Buch der Könige" anführt, so wäre vielleicht eine Lesung „Herrschaft" oder „Macht" möglich.

(199) Zu VETTIUS VALENS sind STEINSCHNEIDER, *Z. D. M. G.*, 50, 342; SUTER : Übers. 21 sowie E. W., B. III, 228 zu vergleichen.

I. Namensformen des PAPPUS : B. līs; T. L. B. S., A. B. Līn S., B. Los. B. L. S. (200).

II. Namensformen des VALENS : Fālīs; Walālīs; Awāl. S.; Wālīs.

Für I. wäre allenthalben eine Konjektur in Form von APOLLONIUS, dessen Namensformen BALĪNŪS, BALĪNĀS, und BALĪS sind, möglich.

Dagegen sind aber folgende Einwände zu erheben : 1. IBN AN-NADĪM *(Fihrist)* sowohl als auch *I. al-Qiftī* (ta'rīkh al-ḥukama') unterscheiden sehr wohl zwischen VALENS und PAPPUS.

2. Ein Zeugnis irgendwelcher Art, dass APOLLONIUS VON PERGE den *Euklid* kommentiert habe, liegt nicht vor.

3. Griechische Schriftsteller, wie PROKLUS, EUTOKIUS, etc. bezeugen, dass PAPPUS tatsächlich einen Kommentar zum *Euklid* geschrieben hat (201).

Diese Punkte sprechen mit Bestimmtheit für eine Lesung von I. in der Form von "PAPPUS". Auch geht aus den Bemerkungen über FĀLĪS hervor, dass es sich hier um einen Astrologen handelt, der sich wohl kaum mit exacten mathematischen Problemen befasst haben wird.

Damit dürfte wohl die Lesung WOEPCKES in der oben zitierten Arbeit, welche auch CANTOR (202) in der 3ten Auflage seines Werkes noch aufgenommen hat, hinfällig sein.

Der Kommentar des PAPPUS zum X. Buche des EUKLIDES aus der arabischen Übersetzung des ABU UTHMĀN AD-DIMIṢḤQĪ wurde von H. SUTER ins Deutsche übertragen. (*A. G. N. M.*, H. W., Erlangen, 10-78, 1922).

AḤMAD B. MUḤ. B. 'ABDALJALĪL, ABŪ SA'ĪD, AS-SIJRĪ (203).

AL-BĪRŪNĪ erwähnt von ihm eine Abhandlung des Titels : Normen für die Mischformen des nördlichen und südlichen Astrolabs (204).

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(200) Punkte bedeuten kurze, aus der Schreibung nicht hervorgehende Vokale (u, a oder i).

(201) HEIBERG : *Literaturgesch. Studien über Euklid*, 162-64.

(202) CANTOR, I_3, 348 u. 425.

(203) SUTER : *Araber*, 80. E. W., B. LVII, 9. B. LX „Über AL-BĪRŪNĪ u. seine Schriften". S. 85 ; KARL KOHL : Zur Geschichte des Dreiteilung des Winkels, *Sitzungsberichte*, 54/55, 180 ff.

Der Beiname AS-SIJRĪ besagt, dass er aus Sijistān stammt.

(204) Solche Mischastrolabien erhält man, wenn ein Teil der Ekliptik von

Der erste, welcher das Beobachtungsastrolab herstellte, ist nach ABŪ SA'ĪD AS-SIJZĪ der aus Qâyin stammende 'ABD ALLĀH URK MARDAN.

Über die in der Chronologie, 43 angegebene Mitteilung des AL-BĪRŪNĪ, dass ihm AS-SIJZĪ Nachrichten über die Monate der alten Bewohner von Sijistān zukommen liess, ist bis jetzt noch nichts Bestimmtes zu äussern.

Zu seiner Abhandlung : Richtigstellung einiger Beweise von Sätzen des ***Euklides*** (Ind., 6 ff., 734, 140) verweise ich auf SUTER : ***Araber***, 80; desgl. sind hier seine anderen Werke aufgezählt.

SA'ĪD B. MAS'ŪD B. AL-QASS.

SUTER (205) hält diesen Autor für identisch mit GHARS AN-NA'MA, ABŪ NAṢR (206). Dieser Autor verfasste möglicherweise Glossen zu Cod. Leid. 965 (399_{10}), welcher die Tractate I-VI der *Στοιχεῖα* des EUKLID in der Übersetzung des ḤAJJĀJ B. YŪSUF enthält.

AṢBAGH B. MUḤ. B. AS-SAMḤ, ABŪ'L-KĀSIM.

Zu diesem Autor, der eine Einleitung (madkhal) in die Geometrie zur Erklärung (fī tafsīr) des ***Euklid*** verfasste, vgl. SUTER : ***Araber***, 85 u. 215 Anm. 52; CANTOR, I_3, 793.

I.AS-SAMḤ war ein Schüler des MASLAMA B. AḤMAD AL-MAJRĪTĪ (207).

IBN SĪNĀ.

Mit dem vollständigen NAMEN AL-ḤUSAIN B. 'ABDALLĀH B. AL-ḤUSAIN B. 'ALĪ ABŪ 'ALĪ, ASH-SHAICH AR-RA'ĪS. Sein abendländischer Name ist AVICENNA, eine latinisierte Form des Hebr. AVEN SĪNĀ (208).

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dem Nord-, ein anderer von dem Südpol aus auf den Äquator projiziert wird.

Unser Autor konstruierte das narzissen-, das muschel-, das krug-, das stier-, das büffel-, das schildkrötenförmige, ferner das anemonen-, das kahn-, das kreuz-, u. das schraubenförmige Astrolab.

(205) Vgl. SUTER : ***Araber***, 227, zu Art. 371 (a).

(206) Vgl. SUTER : ***Araber***, 153.

(207) SUTER : ***Araber***, 76 ; CANTOR, I_3, 909; *I.al-Qiftī*, 326. (Die Übers. entspricht der Mitteilung des Qādī ṢĀ'ID bei SUTER. *l.c.*).

(208) Auf das Leben und Wirken dieses Autors kann ich an diesem Ort nicht eingehen. Ich verweise daher auf die Literaturübersicht von T. J. DE BOER in *Encycl. des Islām*, II, 447; sowie auf die Arbeit von M. A. JOURDAIN: Biographie

Ich werde nur auf seine Beschäftigung mit Mathematik u. Naturwissenschaften zu sprechen kommen und erwähne an erster Stelle einen Traktat AVICENNAS des Titels : fī aqsām al-'ulūm al-aqlīa (über die Teile der philosophischen Wissenschaften), in welcher Abhandlung unser Autor uns eine Einteilung der mathematischen (al-ḥikma ar-riyāḍīya) (209) und der Naturwissenschaften (al-ḥikma aṭ-ṭabī'īya) (210) gibt.

Danach zerfallen die mathematischen Wissenschaften in vier Grundteile : Arithmetik ('ilm al-'adad oder al-arithmāṭīqī), Geometrie (jūmatrīyā oder handasa), Astronomie ('ilm an-nujum oder aṣtrunūmīyā) und Musik (ṣinā'at al-alḥalān oder al-mūsīqī). Diese Einteilung findet sich immer wieder im Mittelalter.

Für sie prägte BOETHIUS das Wort "Quadrivium". Diese vier Grundteile der mathematischen Wissenschaften behandelt IBN SĪNĀ in seiner Schrift kitāb ash-Shifā[1] (Genesung der Seele, liber sufficientiae), welche er in Hamadan verfasste. Zu dieser Schrift ist folgende Stelle aus *I.al-Qiftī*, 420,2 mitzuteilen : "Wenn du damit einverstanden bist, (gemeint ist Jūzjānī, an welchen die Worte gerichtet sind) dass ich ein Buch schreibe, in dem ich nur meine "eigenen Überzeugungen" betreffs dieser (d. h. der griechischen) Wissenschaften vorbringe, so will ich dies gern und unverzüglich tun". In derselben Abhandlung aber führt AVICENNA auch an, dass seine eigenen Überzeugungen in seiner orientalischen Philosophie — gemeint ist seine mystische Philosophie (al-ḥikma al-mushriqīye) (211) — und nicht in seinem kitāb ash-Shifā' nachzusuchen sind. Dieser oben aus QIFTĪ mitgeteilten Stelle kann man wohl kaum besonderen Wert beimessen. Wenigstens gilt das bestimmt für die mathematischen Wissenschaften. Doch genug davon.

Im kitāb ash-Shifā', welches nach neuerer Zählung 21 Bände umfasst, wird in der Geometrie ein Auszug (muḥtaṣar) aus EUKLIDS Elementen behandelt. Dieser mathematische Teil wurde von H. LOKOTSCH mit dem griechischen Texte verglichen und es ergab

abrégée d'ABOU ALY SYNĀ, plus connu sous le nom d'AVICENNE. (*Fundgruben des Orients*, III, 168-77, Wien, 1813). *I. al-Qiftī*, 413-26; CANTOR, I$_3$, 756-57; SUTER: *Araber*, 86 90; KARL LOKOTSCH: AVICENNA als Mathematiker (Diss. 1912).

(209) E. W., B. V, 425.

(210) E. W., B. V, 429.

(211) Vgl. M. HORTEN in *Z. D. M. G.*, 66, 754.

sich eine nur unwesentliche Abweichung des arab. *Euklid* im Cod. Lugd. 1445 von dem griechischen (212).

Ausserdem fügte IBN SĪNĀ dem mathematischen Teil des obigen Werkes einen Auszug aus dem Almagest des PTOLEMÄUS ein (213) sowie ein Kompendium der Arithmetik (214) und der Musik (215).

Die Zweigwissenschaften der mathematischen Wissenschaften sind folgende :

I. Arithmetik : 1. Anwendung der Addition und Subtraktion nach indischer Art, (216); 2. Die Anwendung von al-Jabr wa'l-Muqābala (217).

II. Geometrie : 1. Lehre von der Vermessung; 2. ... den sich bewegenden Vorrichtungen (218) ; 3. ... dem Bewegen der

(212) Vgl. K. LOKOTSCH, AVICENNA als Mathematiker.

(213) *I. al-Qiftī*, 422 : „Was den Almagest anbetrifft, so fügte er zehn Sätze hinzu über die Parallaxe (ikhtilāf al-manẓar) (a) und machte auch am Ende des Almagests einige astronomische Zusätze, auf die keiner vor ihm gekommen war.

Ein Kompendium des Almagests befindet sich auch in cod. Paris. 2484, 1° und in Oxford I. 1012. Vgl. auch Einleitung zu dem astronomischen Teil des Kitāb ash-Shifā'. E. W., B. LXXII, 1926-27.

(214) Von IBN AL-AFKĀNĪ erwähnt, vgl. E. W., B. XIV, 30. Ich halte dasselbe für einen Auszug aus dem Werk der NIKOMACHUS VON GERASA.

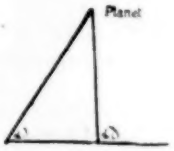
(215) Eine kurze Abhandlung über die Geschichte der Musik mit einer Zusammenstellung der wichtigsten Literatur über dieselbe wurde von E. W. in Beitrag LXVI gegeben. Vgl. auch E. W., B. LVII, 30 (Lehre von den wunderbaren Musikinstrumenten nach H. CHALFA).

(216) Zu Hisāb al-Hind (Das indische Rechnen) siehe E. W., B. XIV, 19; 38.

(217) J. RUSKA übersetzt in seiner Arbeit : Zur ältesten arabischen Algebra u. Rechenkunst, diesen Ausdruck mit Ergänzung und Ausgleichung, d. h. Lehre von den Gleichungen; vgl. auch E. W., B. XIV, 27-28.

(218) Es handelt sich hier um die Mechanik (al-Ḥiyal), welche nach den Mafātiḥ in zwei Abschnitte eingeteilt wird.

(*a*) Die graecisierte Form ist al-barakasīs; ichtilāf al-manzar lautet übersetzt : Unterschied im Anblick.



Ort an der Erdoberfläche — Erdmittelpunkt.

Parallaxe = $\alpha_1 - \alpha_2$

Lasten (219); 4. ... den Gewichten und Wagen (220) ; 5. ... den Teilinstrumenten (Ālāt al-juzīya); 6. ... der Optik und den Spiegeln und 7. die Lehre vom Fortführen der Gewässer.

III. Astronomie : Herstellung der Tafeln (zījāt) und Ephemeriden (taqāwīm) (221).

IV. Musik: Herstellung der wunderbaren, fremden Instrumente, wie der Orgel (222) und was ihr ähnlich ist.

Einteilung der Naturwissenschaften :

1. Physik (223); 2. Himmel und Welt; 3. Entstehen und Ver-

(219) Der erste Abschnitt befasst sich mit dem Fortbewegen der Lasten durch eine kleine Kraft u. den dazu erforderlichen Werkzeugen (āla). Der zweite Abschnitt handelt von sinnreichen Vorrichtungen, d. h. solchen, die sich automatisch bewegen. (E. W., B. VI).

(220) Über Gewichte u. Masse der städtischen Araber sowie der Ärzte geben uns die Mafātiḥ Aufschluss (E. W., B. XXII, 303; 305, woselbst auch von WIEDEMANN eine Tabelle über Arzneigewichte aus dem Schlusse des Kanon des IBN SĪNĀ mitgeteilt wird.)

(221) Definition dieser Wissenschaft der Tabellen und Ephemeriden nach „Qāṣid al-Irshād" (Leitung des Strebenden) E. W., B. IX, 188. Die Wissenschaft der Tabellen und Ephemeriden ist eine Wissenschaft, durch die man die Grösse der Bewegungen losgelöst von allgemeinen Principien kennen lernt. Ihr Nutzen besteht in der Kenntnis des Ortes eines jeden der 7 Planeten (al-kawākib as-sayyāra) im Verhältnis zu seiner Sphäre [falak, σφαῖρα]. Es handelt sich hier offenbar um Intersphären, von welchen mehr oder weniger den einzelnen Planeten zugewiesen wurden. Man versteht darunter den Raum zwischen zwei konzentrischen Kugelflächen. E. W., B. IX, 192; XLVII, 228, ferner KARL KOHL: Über den Aufbau der Welt, (fī hayat al-'Ālam nach IBN AL-HAITHĀM, *Sitzungsberichte*, Erlangen, Bd. 54/55, 140 ff., 1922/23) und der Ekliptik (minṭaqa al-burūg, Gürtel der Tierkreiszeichen), ihres Fortwanderns, ihres Rückkehr (rugū' oder rag'a, d. h. Bewegung in der Ekliptik entgegengesetzt der Reihenfolge der Tierkreiszeichen), ihrer Rechtläufigkeit (Istiqāma ; im Gegensatz zu rugū' erfolgt die Bewegung in der Reihenfolge der Tierkreiszeichen), ihres sich nach Osten (musharriq) (a) und Westen Wendens (taghrīb) (b) und ihrer Erscheinung und ihres Verschwindens zu jeder Zeit und an jedem Ort und dessen, was diesem ähnlich ist von den Aspekten (ittiṣāl) des einen von ihnen zu dem andern und der Sonnen- und Mondfinsternisse und was in ähnlicher Weise sich ereignet.

(222) al-Urghānūn, E. W., B. LXVI.

(223) E. W., B. X., 354 teilt eine Bemerkung aus dem 8. Kap. des zweiten Buches der Physik des Shifa' mit, wonach unter Voraussetzung der Unmöglichkeit der Existenz des leeren Raumes grosse Gewichte mittels kleiner Gefässe gehoben werden können. Hierzu gehört auch AVICENNA's Lehre vom Regenbogen (Qaus al-Qusah), welche von M. HORTEN in der *Meteorol.-Zeitschrift*, 534 ff., 1913 mitgeteilt wird. (Hierzu vgl. auch dessen Gegenüberstellung zu jener des IBN AL-HAITHĀM, wozu KAMĀL AD-DIN AL-FĀRĪSĪ kritisch Stellung nimmt, E. W., B. XXXVIII,

(a) Man sieht den Stern vor Sonnenaufgang im Osten aufgehen.

(b) Man sieht den Stern nach Sonnenuntergang im Westen untergehen.

gehen; 4. die Phänomene (āthār, worunter die Akzidentien der Luft verstanden werden. Vgl. F. DIETERICI : Die Naturanschauung etc., 66, Leipzig, 1876) in der Höhe (Meteorologie); 5. Mineralogie (224); 6. die Pflanzen; 7. die Tiere; 8. der Empfindende und das Empfundene (Psychologie).

Zweigwissenschaften der Physik :

1. Medizin (225); 2. Vorhersagungen aus den Sternen (226) (Astrologie); 3. Physiognomik ('ilm al-Firāsa) (227); 5. Auslegungswissenschaft ('ilm at-ta'bīr) (228); 6. Lehre von den Talismanen (229) (tilasm); 7. Lehre von den Bezauberungen (nīranjīyāt, auch nīranjāt) (230); 7. Die Wissenschaft der Chemie (al-Kīmīyā) (231).

Zwecks weiterer Orientierung verweise ich auf die unten in den Anmerkungen gegebene Literatur.

SINĀN B. THĀBIT B. QURRA, AL-ḤARRĀNĪ, ABŪ SA'ĪD (232), war der Sohn von THĀBIT B. QURRA.

39 ff.). Vgl. IBN SĪNĀs Anschauung vom Sehvorgang in *Arch. f. d. Gesch. d. Naturwiss. u. d. Technik*, IV, 239 ff., 1912.

(224) Zur Mineralogie im Islām, vgl. E. W., B. XXX, 205-56.

(225) Nach IBN SĪNĀ ist das Ziel der Medizin ('ilm aṭ-ṭibb) „die Erkenntnis der Prinzipien des menschlichen Körpers und seiner Zustände in Gesundheit und Krankheit und deren Ursachen und Anzeichen, um die Krankheiten zu vertreiben und die Gesundheit zu bewirken".

(226) Aḥkām an-nujūm; vgl. E. W., B. LVII, 7 (Definition nach IBN SĪNĀ).

(227) „Ihr Ziel ist, aus den äusseren Eigenschaften Anhaltspunkte für den Charakter zu gewinnen".

(228) „Ihr Ziel ist, aus den Traumphantasien Hinweise zu erhalten auf das, was die Seele von der verborgenen Welt wahrnahm, wobei sich die Einbildungskraft dies unter einem anderen Bild vorstellte".

(229) „Ihr Ziel ist, die himmlische Kraft mit der Kraft irgendwelcher irdischer Körper zu vermischen, um sich dadurch eine Kraft zu werben, die eine wundersame Wirkung auf die Welt der Erde ausübt".

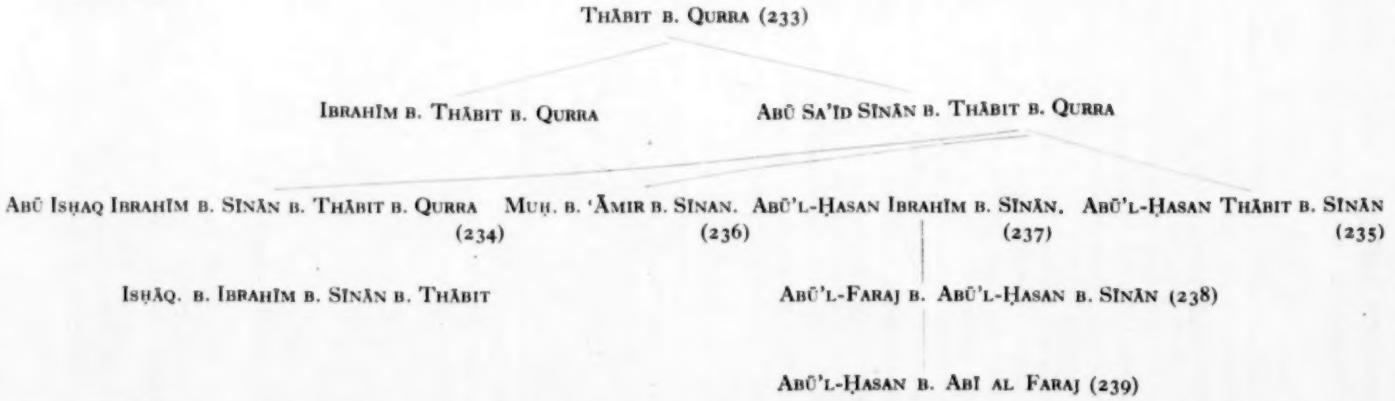
(230) „Ihr Ziel ist, die Kräfte in den Substanzen der irdischen Welt zu mischen, um aus ihnen eine Kraft zu gewinnen, von der eine wundersame Wirkung resultiert". Zu 'ilm an-nīranjāt vgl. E. W., B. V, 430, LVII, 4 (Anm. zum *Fihrist*, 153).

(231) „Ihr Ziel ist den natürlichen Edelsteinen (Mineralien, Metallen) ihre Eigenschaften zu rauben und ihnen diejenigen anderer mitzuteilen, und zwar einigen von ihnen die Eigenschaften von einigen, um zu der Erzielung von Gold und Silber und anderen Metallen zu gelangen".

Zu IBN SĪNĀs Stellung zur Alchemie, welche aus obiger Definition nicht ersichtlich ist, sowie über zwei alchemistische Schriften, die er angeblich verfasst haben soll, vgl. E. WIEDEMANN : Zur Alchemie bei den Arabern, 26-27 (*A. G. N. H.*, Erlangen, H. V).

(232) *Ibn al-Qiftī*, 190-95; SUTER : *Araber*, 51-52; BROCKELMANN, I, 218; CANTOR, I_2, 749.

Genealogie :


Thābit b. Qurra (233)
Ibrahīm b. Thābit b. Qurra
Abū Sa'īd Sīnān b. Thābit b. Qurra
Abū Isḥaq Ibrahīm b. Sīnān b. Thābit b. Qurra (234)
Muḥ. b. 'Āmir b. Sīnan. (236)
Abū'l-Ḥasan Ibrahīm b. Sīnān. (237)
Abū'l-Ḥasan Thābit b. Sīnān (235)
Isḥāq. b. Ibrahīm b. Sīnān b. Thābit
Abū'l-Faraj b. Abū'l-Ḥasan b. Sīnān (238)
Abū'l-Ḥasan b. Abī al Faraj (239)

(233) E. Wiedemann : Über Thābit b. Qurra, sein Leben und Wirken, *Beitrag* LXIV.

(234) Suter : *Araber*, 53 ; Brockelmann, I, 218-19; Cantor, I, 749. *I. al-Qifṭī*, 57-58 : „Ibrahīm b. Sinān b. Thabit b. Qurra aṣ-Ṣābi' al-Ḥarrānī, mit dem Beinamen Abū Isḥāq, hatte ein ausgezeichnetes Wissen in den Zweigen der Wissenschaft, besonders aber in der Geometrie, in welchem Zweige er ganz besonders hervorragte und worin ihm keiner an Scharfsinn gleichkam. Und er verfasste sehr schöne Werke darüber. Ich sammelte meine auf ihn bezüglichen Bemerkungen in eine Dissertation, welche eine Erwähnung dessen, was er verfasst hatte, enthält. Und zu seinen Abhandlungen über die Astronomie gehören gemäss dem, was in der Dissertation mitgeteilt wird, drei Werke : Das erste nannte er Werk über die Schatteninstrumente. Mit seiner Abfassung begann er in seinem 16. oder 17. Jahre. Die Ausführlichkeit, deren er sich dabei bedient hatte, war ihm später zuwider, worauf er eine leichtere Darstellung gab und sie in drei Bücher teilte. Dies geschah in seinem 25. Lebensjahre. In dem zweiten legte er dar, wie sich alle Sonnenuhren (rukhāmāt; Marmorplatten, die als Sonnenuhren dienen) verhalten. Dazu vereinigte er die Gesamtheit der Konstruktionen der ebenen, horizontalen Sonnenuhren zu einer einzigen, die sie alle umfasste. Dabei stellte er für diese den Beweis auf und legte zugleich das Verfahren bei einer Konstruktion ('aml) dar und drittens über den Schatten und darüber, was alle von ihm wissen wollen, und darüber, wie es sich mit den

Ich möchte meine Aufmerksamkeit kurz jener Schrift widmen, welche den Titel trägt : Verbesserung des Buches des PLATON

Schatteninstrumenten verhält, bei denen der Schatten weder [zu] lang noch [zu] kurz ist. Ferner über andere Dinge, deren man bei der Aufstellung der Sonnenuhren bedarf, über die Ermittelung der bei ihnen erforderlichen Ebenen, der Linien der Meridiane etc. [Khaṭṭ niṣf an-nahār, Linie der Taghälfte (linea mediae diei) ist der oberhalb des Horizonts gelegene Teil der Meridiangeraden (μεσυμβρινός, linea medii coeli); gemeint aber sind Khaṭṭ niṣf an-nahār, sowie Khaṭṭ niṣf al-laila, Linie der Nachthälfte (linea mediae noctis), der unter der Horizontlinie gelegene Teil des Meridians]. Dann verfasste er auch ein Buch über das, was PTOLEMÄUS al-Qulūdhī nach der Methode der ebenen (?) Darstellung für die Auffindung der Ungleichheiten der Saturns, Mars, und Jupiters (d. h. der oberen Planeten, al-kawākib al-'ulwīya; sie befinden sich oberhalb der Sonne, d. h. sie stehen weiter ab von derselben als Venus, Merkur u. der Mond, welch letztere al-kawākib al-sifliya, d. h. die unteren Planeten, genannt werden) angewandt hatte. [Es handelt sich hier sicher um die Bestimmung der Ungleichheiten in der Bewegung der Planeten. Eine erste Ungleichheit umfasst die veränderliche Geschwindigkeit u. hat den siderischen Umlauf zur Folge. Eine zweite äussert sich in den Stationen u. Retrogradationen u. entspricht dem synodischen Umlauf. PTOLEMÄUS wählte zur Darstellung der Ungleichheit die epicyclische Bewegung u. den dieselbe tragenden excentrischen (deferierenden) Kreis., etc.]. Er behandelte dies in einer einzelnen Schrift, die er im 24. Lebensjahr vollendete und in der er zeigte, dass, wenn er (PTOLEMÄUS) von dieser Methode abgewichen und zu einer andern übergegangen wäre, er die ebene Darstellung hätte entbehren können, welche er angewandt hatte. Er dagegen schlug einen anderen Weg als den der Vergleichung ein. (Bei dieser Methode wird für den betr. Planeten der Radius des excentrischen Kreises mit dem Radius des Epicycels „verglichen"). Über die Geometrie verfasste er dreizehn Abhandlungen, elf derselben handeln über die sich berührenden Kreise. Er zeigte darin alle möglichen Arten der Berührung von Kreisen und von Linien, die durch [gegebene] Punkte gehen (*a*), etc. Und er verfasste hierauf eine andere Schrift, welche er in 13 Kapitel einteilte (?), worin er 41 schwierige geometrische Probleme behandelte über Kreise und Gerade, über Dreiecke und sich berührende Kreise u. s. w. Er wandte darin die Methode der Analysis an, ohne sich der Synthesis zu bedienen, ausser bei drei, welche der Synthesis bedürfen. Weiter schrieb er eine Abhandlung, worin er die Art u. Weise der Auflösung geometrischer Aufgaben vermittelst der Analysis und Synthesis und anderer Ausführungsarten beschreibt und über die Irrtümer handelt, die den Geometern bei der Anwendung der Methode der Analysis begegnen können, wenn sie dieselbe gemäss ihrer Gewohnheit abkürzen wollen. Er verfasste auch eine scharfsinnige Abhandlung über die Konstruktion der drei Kegelschnitte, in welcher er zeigt, wie auf jedem der drei Kegelschnitte eine beliebige Anzahl von Punkten gefunden werden kann (*b*).

(*a*) Vielleicht war IBRAHĪMB. SINĀN die Schrift des APOLLONIUS περὶ ἐπαφῶν (welche verloren ging) über Berührungen bekannt, worin die spezielle Aufgabe gestellt war : „Einen Kreis zu zeichnen, der drei Bedingungen genüge, deren jede darin bestehen kann, durch einen gegebenen Punkt zu gehen, oder eine gegebene Gerade, oder einen gegebenen Kreis zu berühren".

(*b*) Es handelt sich hier um eine Anlehnung an den Inhalt des Buches IV der

(AFLĀṬUN) (240) über die Elemente der Geometrie, worin er Verschiedenes zu dem Original hinzufügte. Da dieser Name in den Quellen als Aqātun (?) auftritt u. somit dieser Name nicht offensichtlich festlag, so glaubte STEINSCHNEIDER dafür den Namen EUKLID vorschlagen zu können. Nun aber verfasste PLATON, wie aus *Fihrist* u. *Ibn al-Qiftī* hervorgeht, eine Abhandlung über die Elemente der Geometrie, sodass die Lesung PLATON wohl die richtige sein wird. Auch soll SINĀN, wie aus MAS'ŪDĪ, Murūj (Paris) I, 19 hervorgeht, die Staatslehre PLATOS in einem wohl verloren gegangenen Werke untersucht haben.

SIND (SANAD) B. 'ALĪ (241)

I. al-Qiftī, 206 :

SIND B. 'ALĪ, der Astronom AL-MA'MŪN's, war als solcher ausgezeichnet. Er war erfahren im tasyīr der Gestirne und verfasste astronomische Tafeln sowie Astrolabien u. war einer der hervorragendsten zu seiner Zeit. Er stand in Diensten AL-MA'MŪN's, welcher ihn zur Reform der astronomischen Tafeln u. zur Beobachtung nach dem Shammāsīya-Viertel in Bagdad rief (242). Er führte diesen Auftrag aus und fixierte die Lage

(235) *I. al-Qiftī*, 397, 10.

(236) *I. al-Qiftī*, 396, 10.

(237 Vgl. E. W., B. XX, „Einige Biographien nach EL-BAIHAQĪ", wo MUḤ. B. JABIR B. SINĀN, ein beobachtender Astronom, erwähnt wird, welcher nach WIEDEMANN, AL-BATTĀNĪ sein soll. Desgleichen möchte ich noch bemerken, dass *I. al-Qiftī*, 398, einen Bruder ABŪ' L-ḤASAN (THĀBIT) B. SINĀNS, des Namens ABŪ' L-FAḌL B. SINĀN, erwähnt.

(238) *I. al-Qiftī*, 428, 4.

(239) *I. al-Qiftī*, 397, 1.

(240) Zu AFLĀṬŪN vgl. den Artikel von CARRA DE VAUX in der *Encycl. d. Islām*, sowie CANTOR, I_3, 213-14; E.W., B. III, 224; zu einer dem PLATON zugeschriebenen Abhandlung über spezifische Gewichte, siehe E. W., B. VIII, 173-80.

(241) SUTER : *Araber*, 13; CANTOR, I_3, 730. Über seine Beziehungen zu den BENŪ MŪSĀ, vgl. E. WIEDEMANN in *Archiv für Kulturgeschichte*.

(242) Die Leitung dieser Beobachtung unterstand dem Astronomen YAḤYĀ B. ABĪ MANṢŪR (gest. 830 oder 831). Auf Grund der Beobachtungen in Bagdad (*a*) entstanden die „erprobten (?) Tafeln" (al-zīj al-mumtaḥan).

κωνικά (Kegelschnitte) des APOLLONIUS, worin sich APOLLONIUS in einem Sendschreiben an ATTALUS mit der Frage befasst, wieviel Punkte Kegelschnitte mit Kreisperipherien und mit anderen Kegelschnitten gemein haben können. Seine Abhandlung über die Ausmessung der Parabel wurde von H. SUTER in der *Vierteljahrsschrift der Naturforschenden Gesellschaft* in Zürich, 63, 214, 1918 behandelt.

(*a*) Zur Gründung von Bagdad vgl. E. W., LVII, 22.

der Gestirne (al-kawākīb) (243). Er führte wegen des Hinscheidens AL-MA'MŪNS die Beobachtung nicht zu Ende. Und SIND verfasste eine berühmte astronomische Tafel, derselben sich die Astronomen bis zu unserer Zeit bedienten. Er war ein Jude und nahm unter AL-MA'MŪN den Islām an, und er ist derjenige, welcher das Observatorium baute, das sich hinter dem Tore Ash-shammāsīye in der Residenz Bagdad befindet. Und AL-MA'MŪN beauftragte ihn mit der Prüfung der Beobachtungen, als er in denselben mit grossem Scharfsinn hervortrat. Er verfasste berühmte Werke in Astronomie und Arithmetik.

Zur Abhandlung über die Apotomeen und Medialen, wohl eine Abhandlung über das X. Buch des *Euklides* oder einen Teil desselben, vgl. SUTER, *l.c.* (244).

IBN ABĪ'L-SHUKR.

Mit dem vollständigen Namen YAḤYĀ B. MUḤ. B. ABĪ'L-SHUKR MUḤYĪ AD-DĪN AL-MAGHRABĪ, ist der Verfasser einer Redaktion der Elemente des EUKLID, vorhanden in Konstant. 2719. Zu seinem Leben u. Wirken vgl. SUTER : *Araber*, 155-56, sowie STEINSCHNEIDER, *Z. D. M. G.*, *50*, 169.

MUḤ. B. ASHRAF SHAMS-AD-DĪN AS-SAMARQANDĪ.

Er schrieb : Ashkal at-ta' sīs, die Fundamentalsätze, welche Erläuterungen zu 35 ausgewählten Sätzen der ersten Bücher *Euklids* enthalten (Gotha, 1494, 1497 ; Oxford, I, 967, 2° ; Brit. Mus. P. Add. 23570).

Vgl. SUTER : *Araber*, 157; STEINSCHNEIDER : EUKLID *bei den Arabern*, 95; BROCKELMANN, I, 468.

SHAMSI, ABŪ'L-ḤASAN 'ABDALLĀH B. MUḤ. AL-HARAWĪ.

Angeblich der Verfasser einer an einen gewissen 'ADBALLĀH

(243) Darunter sind die Planeten zu verstehen, deren Bewegungen geprüft wurden, wobei vor allem die Ergebnisse mit den Grundlagen (Ekliptikschiefe, Präzession der Nachtgleichen, etc.) des Almagestes verglichen wurden.

(244) *I. al-Qiftī*, 641,9: ... „und SIND B. 'ALĪ hatte es kommentiert". Anm. : SIND B. 'ALĪ wird von AL-KHAZĪNĪ in der Wage der Weisheit (mīzān al-Ḥikma) in dem Abschnitt über spezifische Gewichte auch als Autor angeführt. Nur in *I. al-Qiftī* u. *I. a. Us.* wird bei THĀBIT B. QURRA eine Abhandlung des Titels : Antworten auf eine Anzahl von Fragen, die SANAD B. 'ALĪ an ihn gerichtet hatte, angeführt.

gerichtete Dissertation, welche den Beweis enthält, dass das Buch der Elemente sich auf die Logik gründet. Vgl. STEINSCHNEIDER : *Z. D. M. G.*, 50, 169. SUTER : *Araber*, 57, u. 228. Vielleicht ist er identisch mit YŪSUF AL-HARAWĪ (245) (aus Herāt, einer alten Stadt in Afghānistān).

IBN RUSHD, ABŪ'L-WALĪD MUḤ. B. AḤMAD B. MUḤ. B. RUSHD (246). AVERROES, so ist sein mittelalterlicher Name, soll der Verfasser einer Abhandlung über das sein, was vom Buche des EUKLID für den Almagest [des PTOLEMÄUS] nötig ist.

In seiner Beschäftigung mit den Naturwissenschaften trat er vor allem auf dem Gebiet der Astronomie hervor, wozu folgendes zu erwähnen ist. AVERROES glaubte im 12. Jahrhundert einen Merkurdurchgang durch die Sonne beobachtet zu haben, wobei es sich aber nur um einen Sonnenflecken handelte, ein Beobachtungsfehler, der sich selbst noch bei KEPLER i. J. 1607, wie uns in dessen Abhandlung „Ausführlicher Bericht von dem 1607 erschienenen Haarstern" (Hall, 1608) mitgeteilt wird, vorfindet. Weiter versuchte IBN RUSHD die Hypothese des EUDOXUS über die konzentrischen Sphären aufzufrischen, von dessen System er aber keine vollständige Darstellung aus Zeitmangel geben konnte. Es handelt sich bei den Sphären des EUDOXUS um die Darstellung der Stationen und Retrogradation mittelst Kombination verschiedener Kreisbewegungen, was EUDOXUS dadurch gelang, dass er die scheinbare Bewegung eines jeden Planeten (es handelt sich hier nämlich um das geozentrische Weltsystem von PYTHAGORAS !) in eine Anzahl gleichförmiger Elementarbewegungen zerlegte, deren jede durch eine um 2 Pole rotierende Sphäre darstellbar war. Diese Sphären verband er derart, dass er die Achse jeder folgenden Sphäre durch die vorhergehende tragen liess, wobei er den Planeten selbst in den Äquator der letzten Sphäre versetzte (247). Die Planeten bewegen sich hierbei in spiralförmingen (laulabī) Bahnen, welche die Form eines ∞ haben, wobei diese $\backsim$ Bewegung in der östlichen, die andere $\sim$ in der westlichen Hemisphäre erfolgt.

(245) *I.al-Qiftī*, 391.

(246) SUTER : *Araber*, 127; CARRA DE VAUX in *Encycl. d. Isl.*, II, 436-39 ; STEINSCHNEIDER, *Z. D. M. G.*, 50, 127.

(247) Vgl. R. WOLF : *Handbuch der Astronomie*, I, 517 ((254).

AR-RĀZĪ (248).

Ibn al-Qiftī, 291 :

MUḤ. B. 'UMAR B. AL-ḤUSAIN, ABŪ AL-FAḌL AL-FAḪR AD-DĪN (249) AR-RĀZĪ, bekannt unter dem Namen IBN AL-KHAṬĪB, lebte zu unserer nächstliegenden Zeit (250). Er betrieb mit grossem Erfolg die Wissenschaften der Anfänge ('ulūm al-awā'il) und drang tief ein in die Wissenschaft der Elemente (251). Er ging nach Chorāsān und stiess dadurch auf ein Werk des ABŪ 'ALĪ B. SĪNĀN und AL-FĀRĀBĪ, woraus er sehr viel lernte. Dann reiste er nach Transoxeanien (252), um mit den BANŪ MĀZA zusammenzukommen, bei welchen er jedoch keine gute Aufnahme fand. Er war danach sehr bedürftig. Und es berichtete mir DĀ'ŪD AṬ-ṬAIYIBĪ at-tājir (Der Kaufmann), bekannt unter dem Namen AN-NAJĪB „der Edelmütige" — und er pflegte teilzunehmen an den Angelegenheiten der Leute. Ich sah IBN KHATĪB krank in Buchara in einer unbekannten Schule. Und er klagte mir sein Leid. Darauf kam ich mit den Kaufleuten, die sich der arabischen Zivilisation angeschlossen hatten, zusammen und erhielt von ihnen etwas von der Almosensteuer ihres Vermögens, was ich ihm zukommen liess. Darauf kehrte er von Buchara zurück und begab sich nach Khurāsān. Und es ereignete sich zufällig, dass er mit KHWĀRIZMISHAH MUḤ. B. TUKUSH zusammentraf (253). Darauf näherte er sich ihm, und dieser zog ihn in

(248) SUTER : *Araber*, 132 ; BROCKELMANN, I, 506; T. J. DE BOER : *Gesch. d. Philosophie im Islām*, 73 (1901); M. HORTEN : *Die Philosoph. Ansichten von* RĀZĪ u. ṬŪSĪ, 195 ff. u. 197 ff., Bonn, 1910 ; E. WIEDEMANN in *Eders Jahrbuch*, 65 ff., 1913.

(249) AL-FAKHR AD-DĪN ist ein Beiname und heisst „Der Ruhm der Religion". Diesen Beinamen führt auch ein Drusenfürst namens FAḪR AD-DĪN B. KORḲMAS (geb. 1572 gest. 1635 durch Henkershand).

(250) Gemeint ist die Zeit I. AL-QIFṬĪ's. Dieser lebte 568/1172-646/1248 und unser Autor 544/1150-606/1210.

(251) 'Ilm al-uṣūl; möglicherweise sind hierunter die Elemente des EUKLID verstanden.

(252) mā warā'a an-nahr „was hinter dem Fluss gelegen ist" gemeint ist der Oxus (al-Jaiḥūn), heute Āmū-Daryā nach der Stadt Āmul, später Āmuya (heute Tscharjui), genannt.

(253) FAKHR AD-DĪN MUḤ. B. 'UMAR AR-RĀZI widmete diesem Sultan eine Abhandlung über die Tagewählereien (Al-Ikhtiyārāt, al-ikhtiyārāt al-'Alā'īya fī'l-ikhtiyārāt as-samāwīye). Zu einer Abhandlung Al-Ikhtiyārāt al-'alāi'ya wa darag al-Falak (Die Tagewählereien auf Grund der hohen Himmelszeichen und die Grade der Himmel), vgl. E. W., B. LVII, 9-10.

seine nähere Umgebung, erhöhte seinen Rang so wie sein Eigentum. Und er wählte Harāt als Wohnsitz, woselbst er ein Grundstück erwarb und Kinder zeugte. Und er blieb daselbst, bis dass er starb. Er wurde ausserhalb von Harāt, in dessen Nähe, an einem Berg begraben. Und das gilt als sein Grab. Die Wahrheit ist aber, dass er in seinem Haus begraben wurde, weil man fürchtete, dass die Masse an seiner Leiche ein Exempel statuieren wollte wegen seines Glaubens an den Intiḥlāl (254).

Und er schrieb Abhandlungen über die Elemente und Logik und verfasste einen grossen Kommentar zum *Qurān*. Sein Wissen ist aus den Abhandlungen der Früheren und Späteren geschöpft, was derjenige erkennt, der auf sie stösst.

Und ich sah in der Chronik eines Späteren die Erwähnung des FAḤR AD-DĪN B. AL-KHATĪB. Dort sagte er : MUḤ. B. 'UMAR AL-ḤUSAIN AR-RĀZI ABŪ AL-MU'ĀLĪ, bekannt unter dem Namen IBN KHATĪB AR-RAY FAḤR AD-DĪN, gehörte zu den ausgezeichnetsten seiner Zeit.

Er überragte die Früheren im Fiqh (255), der Wissenschaft der Elemente (256), der Wissenschaft des Kalām (257) und der Philosophie (Ḥīkma) (258). Und er widerlegte ABŪ 'ALĪ B. SĪNĀN und korrigierte ihn. Sein Rang war ausgezeichnet in Chorāsān und seine Werke wurden in den Ländern verbreitet. Die Gesetzeskundigen benutzten sie. Er bekämpfte die Karrāmīten (259)

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(254) Ich glaube, dass dieser Begriff speziell die Bedeutung von Ḥulūl als unio substantialis eines göttlichen Geistes mit dem Menschen (Ḥulūl al-'aql al-fa"āl fi'l-Insān) wiedergibt, wodurch die Zerstückelung des göttlichen Wesens gegeben wäre.

(255) Fiqh „Einsicht, Vernünftigkeit" ist der Name der Gesetzeswissenschaft im Islām (jurisprudentia rerum divinarum atque humanarum notitia).

(256) 'ilm al-uṣūl könnte eventuell auch die Bedeutung von uṣul al-fiqh haben, d. h. die Lehre von den „Wurzeln" des Rechtes (Gesetzquellen, Methodologie u. ihre Anwendung) bedeuten.

(257) kalām „Rede, Sprache, Dogmatik". Ihre Vertreter nennt man Mutakallimūn. Diese machen „die Lehrsätze, die vom religiösen Glauben als der Diskussion nicht unterworfene Wahrheiten hingenommen werden, zum Gegenstande der Erörterung". (GOLDZIEHER, *Vorl. über den Islām*, 100 ff., 127 ff., 1910.

(258) Ḥikma wird nach H. Ch., III, 84 definiert als „die Erforschung der wirklichen Natur der Dinge, wie sie in sich sind, soweit das dem Menschen möglich ist". Dieser Ausdruck wurde schliesslich gleichbedeutend mit Falsafa, worunter ursprünglich die griechische Richtung der islāmischen Philosophie verstanden wurde. Dieser Ausdruck Ḥikma kommt auch zur Bezeichung der Alchemie vor.

(259) Es sind dies Anhänger der Sekte Karrāmīya, benannt nach ABŪ 'ABDALLĀH

und machte ihre Fehler offenkundig. Weiter wird berichtet, dass sie soweit gingen, ihm Gift zu geben, worauf er umkam. Und er pflegte zu reiten und es umstanden ihn Truppen mit gezückten Schwertern und viele Mameluken nannte er sein eigen; ausserdem stand er in hohem Ansehen bei den Fürsten von Khwārizm (260). Er empfand ein heftiges Verlangen nach Beschäftigung mit der Alchemie, wofür er ein grosses Vermögen verschleuderte. Jedoch, er hatte keinen Erfolg darin. Sein Geburtstag fällt in das Jahr 543, u. er starb in Harāt im Dhū'l-ḥijja (261) des Jahres 606. Abhandlungen :

1. Kommentar zu den muṣādarāt des EUKLID (nicht vorhanden).
2. Werk über die Geometrie (ebenfalls nicht vorhanden).

Zu der Abhandlung des AR-RĀZĪ über Chiromantik, welches auf ein gleichnamiges Werk des ARISTOTELES zurückgehen soll, vgl. E. W., B. XVII, 97-98; STEINSCHNEIDER : *Beiheft zum Zentralblatt für Bibliothekswesen*, 12, 80-81, 1893.

Zu einer Abhandlung unseres Autors über optische Täuschungen, wobei es sich um eine Erörterung der Vermittelung sicherer Erkenntnisse durch die Sinne oder durch den Verstand handelt, verweise ich auf E. W., B. XXXIII „Über optische Täuschungen nach FAKHR AD-DĪN AR-RĀZĪ und NAṢĪR AD-DĪN AṬ-ṬŪSĪ", 154-67.

Für sonst in Betracht kommende Abhandlungen ist SUTER : *Araber*, 132 einzusehen.

ABŪ YŪSUF YA'QŪB B. MUḤ. AR-RĀZĪ (262).

Über sein Leben ist uns nichts bekannt. Er kommentierte in Auftrage von IBN AL-'AMĪD (263) den Xten Traktat der Elemente des EUKLID.

MUḤ. B. KARRĀM (gest. 255/868/69). Nach dessen Ansicht ist das göttliche Wesen eine Substanz (jauhar) ohne menschliche Glieder und in Kontakt mit dem Thron, der im Raume lokalisiert ist. M. HORTEN : *Die philosophischen Systeme*, 340 ff.

(260) Khwārizm oder Khūva ist eine Landschaft am unteren Lauf des Amū-Daryā (Oxus).

(261) Monat der Pilgerfahrt nach Mekka (der zwölfte Monat).

(262) SUTER : *Araber*, 66 u. 212,32; *Ibn al-Qiftī*, 64,21.

(263) Es handelt sich hier wohl, wie SUTER auch vermutet, um den Vezīr ABŪ'L-FAḌL MUḤ. B. ABĪ' ABDALLĀH AL-ḤUSAIN B. MUḤ. AL-KĀTIB (gest. i. J. 359/969/70 oder 360), vgl. SUTER: *Araber*, 59 sowie AMEDROZ: The vizier ABU-L-FAḌL IBN AL-'AMĪD, in *Der Islām*, III, 323-51.

MUḤ. B. MUḤ. TARKHĀN B. ANZLAG, ABŪ NAṢR, AL-FĀRĀBĪ (264).

Für das Leben und Wirken unseres Autors bieten untengenannte Arbeiten einen umfassenden Einblick, sodass ich auf ein Eingehen darauf verzichten kann. Ich möchte nur die Bibliographie AL-FĀRĀBĪS, soweit sie in unserem Interessensgebiet liegt, hier anführen (265).

1. Über die Aufzählung der Wissenschaften (De scientiis) (266).

Mathematik :

2. Kommentar über *Euklid.*

3. Erklärungen der muṣādarāt des I. u. Vten Tractates des EUKLID (267) (STEINSCHNEIDER: Hebr. Übers., 509).

4. Einleitung in die reine Geometrie, Kompendium.

5. Kommentar über den Almagest de PTOLEMÄUS (268).

Astronomie : (269)

6. Das Buch der Gestirne.

7. Über die Einwirkungen aus der Höhe, in Form von Glossen.

8. Abhandlung über das, was wahr und was falsch ist von den astrologischen Urteilen.

9. Abhandlung darüber, dass die Bewegung der himmlischen Sphären eine bleibende sei (270).

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(264) SUTER : *Araber*, 54; *Ibn al-Qifṭī*, 277 (Übersetzt in ALFĀRĀBĪS *Philosoph. Abhandlungen* von DIETERICI, 115 ff., Leiden, 1890); M. STEINSCHNEIDER : AL-FĀRĀBĪ, des arabischen Philosophen Leben und Schriften, in den *Mémoires de l'Acad. impériale des Sciences de St. Pétersbourg*, 13, N° 4 (Petersburg, 1869); BROCKELMANN, I, 210-13.,

Auch möchte ich auf den Artikel von B. CARRA DE VAUX in der *Encycl. d. Islām*, II, 55-57, hinweisen.

(265) Eine ausführliche Bibliographie teilt M. HORTEN in : *Das Buch der Ringsteine* FĀRĀBĪS, xviii-xxviii, Münster, 1906 mit.

(266) Der arabische Titel dieser Schrift ist Iḥṣā al-'ulūm (vgl. *I. al-Qifṭī*, 277-78). Zu dieser Abhandlung, vgl. E. W., B. XI *(Über al-Fārābīs Aufzählung der Wissenschaften)*.

(267) Wie CASIRI : *Bibliotheca Arabico-Hispana*, I, 299, Nr. 8 erwähnt, sollen im Escurial 879 vier Schriften FĀRĀBĪS über EUKLID genannt sein.

(268) Es handelt sich hier um einen Kommentar zur Übersetzung des Almagestes von THĀBIT B. QURRA.

(269) Die Astronomie ist nach FĀRĀBĪ in Astrologie u. die wissenschaftliche Astronomie eingeteilt.

(270) Die Lehre von der Bewegung der Himmelskörper gehört nach AL-FĀRĀBĪ zur 2ten Rubrik der in 3 Rubriken eingeteilten theoretischen Astronomie. Auch möchte ich noch hinzufügen, dass AL-FĀRĀBĪ besonders betont, die Erde habe weder translatorische noch rotatorische Bewegung, d. h. sie ist absolut ruhend. Dies geht auf die Annahme des PYTHAGORAS zurück, wonach die Erde eine frei-

10. Kommentar über das Buch des ARISTOTELES vom Himmel und der Welt (as-Samā' wa'l-'Ālam) (271).

11. Kommentar des Buches der Meteore in Form von Anmerkungen.

Alchemie :

12. Abhandlung über die Notwendigkeit der Kunst der Alchemie und Widerlegung derjenigen, die dieselbe für nichtig halten (272).

Physik :

13. Werk über die sinnreichen Anordnungen (al-Ḥiyal) (273).

14. Werk über die sinnreichen geometrischen Anordnungen (al-Ḥiyal al-Handasīya).

15. Kommentar über die Physik, in Form von Glossen (274).

16. Buch der spezifischen Kräfte.

17. De tempore.

18. Über das Atom und das Teilbare.

19. Über das Leere.

20. Über das Umfassende, den Raum und das Maass der Bewegung.

21. Über die veränderlichen vorhandenen Dinge.

22. Über Werden und Vergehen, erwähnt bei AVERROES.

TAQĪ AD-DĪN ABŪ'L-CHAIR MUḤ. B. MUḤ. AL-FĀRISĪ war ein Schüler des MANṢŪR B. ṢADR AD-DĪN MUḤ. GHIYĀTH AD-DĪN AL-ḤUSAINI (gest. 949/1542) (275). Von AL-FĀRISĪ ist zu bemer-

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schwebende Kugel im Mittelpunkt der Welt ist. Zu dieser Vorstellung wurde er wahrscheinlich durch die Lichtgestalten des Mondes hingeleitet. Vgl. OTTO FRIEDRICH Gruppe in : *Die Kosmischen Systeme der Griechen*, Berlin, 1851.

(271) Zu Arisṭūṭālīs, vgl. T. J. DE BOER in *Encycl. d. Islām*, I, 449-51. Bei dem o. a. Buch über die Einwirkungen aus der Höhe handelt es sich um die Meteorologie (al-athār al-'alawīya).

(272) E. WIEDEMANN : *Journ. für prakt. Chemie*, 76, 115, 1907.

(273) Ob diese Schrift fi'l-ḥiyal von ABU FĀRĀBĪ selbst verfasst ist, oder letzten Endes nur ein Kompendium der Aristotelischen Abhandlung „Kitāb al-ḥiyal", worunter dessen Mechanik verstanden ist, sein soll, bleibt fraglich. Doch glaube ich annehmen zu dürfen, dass diese Abhandlung (vgl. *Ibn Al-Qifṭī*, 280) wohl kaum identisch sein dürfte mit der Abhandlung fi'l-Ḥiyal al-Handasīya (CASIRI, I, 193). Es handelt sich hier wohl um eine Ausführung über die geometrischen Ingenia speziell (vgl. E. W., B. XI, 97-98; B. X, 347-48).

(274) Gemeint ist die Physik (as-Samā' aṭ-ṭabī' oder Sam'u'l-kiyān) des ARISTOTELES.

(275) STEINSCHNEIDER : *Euklid bei den Arabern*, 92; SUTER : *Araber*, 189.

ken, dass er seiner Abhandlung über Mathematik den Kommentar Ṭūsī's einschaltete.

Qāḍī-Zādeh ar-Rūmī (276), mit dem vollständigen Namen Mīsā b. Muḥ. b. Maḥmūd schrieb einen Kommentar zu den Fundamentalsätzen des Muḥ. b. Ashraf as-Samarqandī mit den Elementen des Euklid und der Biographie desselben. St. Petersb. 133,3 u. 241,2°; Kairo, 196; Konstant., 2640, 2661, 2743 u. 2744. Sein Enkel ist Maḥmūd b. Muḥ. b. Qādī-Zādeh ar-Rūmī (277).

(Fortsetzung folgt)

Koblenz a/Rh. Dr. A. G. Kapp.

(276) Suter: *Araber*, 174; Brockelmann, II, 212.
(277) Suter: *Araber*, 188; Brockelmann, 447.

Ibn An-Nafis (XIIIth cent.) and his theory of the lesser circulation.

A. — Introduction (1).

The discovery of the circulation of the blood came at a very late period in the history of science. The knowledge of heart and blood-vessels held by the Egyptians and early Greeks—even by such great intellects as Hippocrates and Aristotle—was rudimentary, but the Alexandrian School (Herophilos, Erasistratos, IIIrd Cent. B. C.) succeeded in forming an approximate idea of the anatomical conditions of the vessels connecting heart and lungs. This knowledge was widened by the physiological experiments of Galen (129-201 A. D.), who at the same time enunciated his theory of the movement of the blood which was destined to rule in Medicine for fourteen centuries. According to him, the blood (formed from aliments within the liver) flowed through the hepatic veins to the right ventricle of the heart, whence it passed into the *sinus venarum* and the two *venae cavae*. It rose partly through the pulmonary artery (called "the arterious vein", *vena arteriosa*) into the lungs in order to nourish them, while another and very small part of it passed directly through invisible pores of the *septum cordis* into the left ventricle. Here it was mixed, according to Galen, with the respirated air which came down from the lungs through the pulmonary

(1) Bibliographical references in this article are to :

Brockelmann, *Geschichte der arabischen Litteratur*. Weimar 1898-1902, 2 vols.

Ahlwardt, *Die Handschriftenverzeichnisse der Königlichen Bibliothek zu Berlin*. Bd. XVII : *Verzeichnis der arabischen Handschriften* (Berlin, 1893), vol. V.

Ibn Abī Uṣaibi'a, *'Uyūn al-Anbā' fī Ṭabaqāt al-Aṭibbā'* ("Sources of Information about the Classes of Physicians"). Cairo, 1882, 2 vols.

Leclerc, Lucien, *Histoire de la médecine arabe*. Paris, 1876, 2 vols.

Sarton, George, *Introduction to the History of Science*. Vol. II (Baltimore, 1931), 2 parts. I am indebted to my friend, Professor Roy Dobbin, (Cairo, Faculty of Medicine) for some corrections and suggestions.

vein (" venous artery," *arteria venosa*), and thus it formed a thin, aerated blood, called *vital spirit*, which was carried by the aorta and its branches to all the organs of the body. The venous blood furnished the aliments, the " vital spirit ", the vital power to the organs. It is evident that there was no question of any *circulation* of the blood because *Galen* never speaks about the *reflux* of the blood. He, himself, does not seem to have formed a clear idea of the whole process. We must suppose that he thought the quantity of blood in the human body to be much less abundant than it is in reality. So he could suppose that the blood was continually created (or renewed) by the liver and carried to the peripheral organs where it perished. This theory was accepted by the Hellenic, Syriac and Islamic physicians of the following centuries. It was formulated in an organised system by IBN SĪNĀ *(Avicenna)* in his great Handbook of Medicine (*Qānūn fi't-Ṭibb*, Canon Medicinae). It was transmitted, in Latin translation, to the medical science of Western Europe, accepted by it, and was not even contested by VESALIUS, the great reformer of Anatomy (1543 A. D.).

It was not till 1553 that the Spaniard, MIGUEL SERVETO (MICHAEL SERVETUS), a theologian who had acquired medical knowledge (2), wrote a passage, destined to be famous, regarding the transmission of the blood from the right to the left ventricle through the lungs. This passage, which we quote at the end of this essay, occurs in SERVETUS' book *Christianismi Restitutio* which excited the indignation of Catholics as well as Calvinists and caused the author to be imprisoned and burned—together with his book—at Geneva, in October, 1553. Six years later, the Italian, REALDO COLOMBO, professor of Anatomy at Padua, wrote a book, *De Re Anatomica*, in which he explained the lesser or pulmonary circulation in the same manner as SERVETUS, but in other terms and independently of him. This latter fact has been proved by CAPPARONI in his recent publication (3).

Then followed the first good description of the valves of the

(2) His most recent biography is by J. GOYANES, *Miguel Serveto, teologo, geografo y medico...* Madrid, 1933.

(3) P. CAPPARONI, La storia della scoperta della circolazione del sangue. Siena, 1932.

veins, in 1603, by FABRICIUS OF AQUAPENDENTE, professeur of Anatomy at Padua, who studied the circulation of the blood by ligation of the veins, and the explanation of features of the *general* circulation by ANDREA CESALPINO. But the methodical and experimental exposition of the entire circulation still stands, in the opinion of most medical historians, to the credit of WILLIAM HARVEY (1628). The third centenary of the experimental proof of his great discovery was celebrated a few years ago.

Such was the condition of historical knowledge when, in 1924, a young Egyptian physician, MUḤYĪ AD-DĪN AṬ-ṬAṬĀWĪ, presented before the Medical Faculty of Freiburg (Breisgau, Germany) his thesis for the doctorate (4) on the discovery of the lesser circulation by an Arab physician AL-QURASHĪ (called IBN AN-NAFĪS) of Damascus, who lived in the XIIIth Cent. A. D. ṬAṬĀWĪ quoted some passages from AL-QURASHĪ's work, *Commentary on the Anatomy of Ibn Sīnā*, which he had studied in the MS. (Mf. 912) of the Prussian State Library in Berlin. Unhappily, the thesis in question could not be printed, and only five typewritten and manuscript copies were made. Professor PAUL DIEPGEN, Director of the Berlin Institute for the History of Medicine, drew my attention to this thesis in 1930, and asked me to verify its contents. Having checked the Arabic quotations in the original MS., I wrote a short analysis of Dr. ṬAṬĀWĪ's thesis in order to save it from oblivion, and Dr. G. SARTON was kind enough to recount my personal communications on this subject in his great History (5). Prof. DIEPGEN intended to entrust to a Berlin lecturer on Arabic a more extensive publication of ṬAṬĀWĪ's findings. As this gentleman, after two years' delay, gave no sign of life, and as Dr. ṬAṬĀWĪ, being in the Egyptian Public Health Service, was frequently transferred to small provincial towns and was unable to carry further his own discovery, Prof. DIEPGEN asked me to assume this task. I was fortunate enough to procure two other MSS. of the Arabic

(4) MOHYI EL-DIN EL-TATAWI, Der Lungenkreislauf nach EL-KORASCHI. Inaug.-Diss. Freiburg i. Br., 1924.

(5) GEORGE SARTON, Introduction to the History of Science. Vol. II, Baltimore, 1931, p. 1100. See also SARTON's Arabic account in his paper Al-'ulūm wal-'umrān fī-l-a'ṣur al-wusṭā (Al-Kulliya, vol. 18, p. 373, Bairût, 1932; reprint, pp. 13-14).

text (6), and was able to publish it, with a German translation, commentary and a biography of the Arabic author (7). I propose to give here an extract from this communication, the complete translation of which would be too bulky for publication in a periodical.

B. — A Short Sketch of Medical Life in Damascus and Cairo during the XIIIth Century A. D.

The most important events concerning Medicine during the XIIth Cent. were the foundation of the Nūrī Hospital *(al-Bīmāristān an-Nūrī)* at Damascus after its conquest, in 1154, by the energetic Turkish Sultan, Nūr ad-Dīn Maḥmūd ibn Zengī, the warlike enemy of the Crusaders, and the construction of the Nāṣirī Hospital *(al-Bīmāristān an-Nāṣirī)* in Cairo about 1172 by Salāḥ ad-Dīn, who is no other than the great Sultan Saladin of Egypt and Syria (8). The reputation of these hospitals attracted prominent medical men, most of them pupils of the eminent Christian physician, Amīn ad-Daula ibn at-Talmīdh (of Baghdad, d. in 1164 A. D.). They flocked at first to Damascus and brought with them, among others, copies of Ibn Sīnā's (Avicenna's) great textbook, the *Canon Medicinae* (9), which was eagerly studied and commented by such eminent physicians as Fakhr ad-Dīn al-Māridīnī (10), Ibn an-Naqqāsh, Ibn al-Maṭrān, owner of a great medical library, and Raḍī ad-Dīn ar-Raḥbī, who died in 1233 nearly a centenarian (11). The most prominent pupil of the last-named two scholars was Muhadhdhib ad-Dīn 'Abd ar-Raḥīm ibn 'Alī, called ad-Dakhwār (12) who

(6) See below, p. 114.

(7) Max Meyerhof, Ibn an-Nafīs und seine Theorie des Lungenkreislaufs. (*Quellen und Studien zur Gesch. d. Naturwiss. u. d. Medizin.*, Vol. IV). Berlin, 1933, pp. 37-88, with an Arabic text of 28 p.

(8) See Ahmed Issa Bey, Histoire des Bimaristans (hôpitaux) à l'époque islamique. Le Caire, 1928 and 1930. (*Isis* 14, 535; 18, 491.)

(9) MS. copies of such a voluminous work were very expensive and rare.

(10) Ibn Abī Uṣaibi'a, II, 239. Lecl., II, 27.

(11) Ibn Abī Uṣaibi'a in his volume II, 201-74 furnishes rich material concerning these physicians.

(12) Sarton, II, 1099, note.

lived from 1169 to 1230, began his career as an oculist in the Nūrī Hospital at Damascus, was appointed, about 1210, by Sultan SAIF AD-DĪN, SALADIN's brother and successor, Chief Physician of Syria and Egypt; he gave at the same time medical instruction to many physicians, among whom was IBN ABĪ UṢAIBI'A himself, the historian of Arabic Medicine. AD-DAKHWĀR at his death bequeathed his house and library to form a Medical School *(al-Madrasa ad-Dakhwāriyya)*, which seems to have existed a considerable time and educated a series of prominent medical men. One of the successors of AD-DAKHWĀR was BADR AD-DĪN AL-MUẒAFFAR IBN QĀḌĪ BA'LABAKK (" the son of the judge of Baalbek "), who was director of the Dakhwāriyya School and caused the Nūrī Hospital to be rebuilt, enlarged and supplied with running water, in 1239 A. D. (13). IBN ABĪ UṢAIBI'A gives a very vivid narrative of the intense medical activity of DAKHWĀR's pupils in Damascus and Cairo, most of whom were his contemporaries, colleagues or friends. It is most surprising that he entirely omits any mention of the name of IBN AN-NAFĪS (14) as the latter must have been in charge of the Nāṣirī Hospital in Cairo at the same time as IBN ABĪ UṢAIBI'A himself was there, and, moreover, IBN AN-NAFĪS was during some time Chief of the Physicians in Egypt. It may be the cause of this omission was professional jealousy. Lacking biographical notes by IBN ABĪ UṢAIBI'A, which, as is well known, excel in their competence and exactitude, I tried to find other sources of information on the life of IBN AN-NAFĪS. I came across some nine biographies in ordinary biographical works (15), three of them published in French. They were all very short except two, which are long and nearly identical in matter. Neither of them give exact dates of the main events in IBN AN-NAFĪS' life, but they are full of details which are not devoid of interest. These two biographies have not been hitherto published. One of them is due to IBN FAḌLALLĀH AL-'UMARĪ (16),

(13) IBN ABĪ UṢAIBI'A, II, 244 et seq.

(14) See concerning him BROCKELMANN, *Gesch. d. arab. Lit.* Vol. I, Weimar, 1898, p. 493, and SARTON, II, p. 1099.

(15) See my publication of the full translations in *Quellen u. Studien.*

(16) SHIHĀB AD-DIN AḤMAD IBN FAḌLALLĀH AL-'UMARĪ, *Masālik al-Abṣār*

who died in the great plague at Damascus in 1348, the other by the well-known historian, KHALĪL IBN AIBAK AṢ-ṢAFADĪ (17), a contemporary of the former, but deceased fifteen years after him. It is very probable that AṢ-ṢAFADĪ, a well-known compiler, copied his biographical note from that given by AL-'UMARĪ. Each of the two records, however, adds somewhat to the other. As the text of AṢ-ṢAFADĪ, supplied to me by Dr. GABRIELI, is better than that of AL-'UMARĪ, I give the translation of the former with a supplement from the latter.

C. — THE BIOGRAPHY OF IBN AN-NAFĪS ACCORDING TO AṢ-ṢAFADĪ AND AL-'UMARĪ.

From the *Wāfī bi'l-Wafayāt* of KHALĪL B.AIBAK AṢ-ṢAFADĪ (MS. Brit. Mus., Or. 6587, fols. 20 v.-21 v.)

'ALĪ B.ABI'L-ḤAZM (in the text ḤARAM): He is the excellent Imām, the highly learned Doctor, 'ALĀ' AD-DĪN IBN AN-NAFĪS AL-QURASHĪ AD-DIMASHQĪ (18). The learned ATHĪR AD-DĪN ABŪ ḤAYYĀN (19) gave me the following information:

The aforementioned grew up in Damascus and there occupied himself with Medical Science under MUHADHDHIB AD-DĪN AD-DAKHWĀR. AD-DAKHWĀR was an excellent scholar and had many pupils, among them AR-RAḤBĪ (20), IBN QĀḌĪ BA'LABAKK (21), and SHAMS AD-DĪN AL-KULLĪ (22). 'ALĀ' AD-DĪN was a leader

fī Akhbār Mulūk al-Amṣār. MS. in Cairo Egyptian Library, 99, *Mīm Ta'rīkh*, Vol. VII.

(17) KHALĪL IBN AIBAK AṢ-ṢAFADĪ, *Al-Wāfī bi'l-Wafayāt*. MS. Brit. Museum, Or. 6587, fols. 20 v.-21 v. I am very much indebted for a copy of these pages to the great kindness of Dr. FRANCESCO GABRIELI of Rome.

(18) I. e. from Damascus.

(19) ATHĪR AD-DĪN ABŪ ḤAYYĀN MUḤAMMAD IBN YŪSUF AL-ANDALUSĪ was born in 1256 at Granada in Spain, emigrated to Egypt where he became a reputed theologian, jurist and philosopher, and died in 1345 in Cairo. AL-'UMARĪ and AṢ-ṢAFADĪ were his pupils.

(20) Son of the above-mentioned RAḌĪ AD-DĪN AR-RAḤBĪ, AD-DAKHWĀR's teacher: his name was SHARAF AD-DĪN AR-RAḤBĪ.

(21) BADR AD-DĪN AL-MUẒAFFAR, " the Son of the Judge of Baalbek." Vide supra, p. 104.

(22) SHAMS AD-DĪN MUḤAMMAD IBN IBRĀHĪM was a Hispano-Moorish physician who came to Damascus and acquired there such an intimate knowledge of the

in the Art of Healing, in which no one equalled him in keenness of investigation and discovery. He worked hard at it up to his old age and wrote about it (Medical Science) outstanding works and lucid books. He wrote the " Comprehensive Book of Medical Science," the index of which shows that it should consist of 300 single volumes; so I was told by one of his friends; he made a fair copy of 80 of them; these are now a bequest to the Manṣurī Hospital in Cairo. Also the " Well-Arranged Book on Ophthalmology " and the " Commentary on the *Canon* of IBN SĪNĀ " in several volumes, and others on Medical Science; this was his main sphere. Someone who saw him writing, informed me that he used to write down from memory without consulting a book while writing.

He also had knowledge in Logic and wrote concerning it a Compendium and a Commentary on the *Hidāja* of IBN SĪNĀ on Logic (23). In this science he leaned exclusively towards the methods of the earlier writers, as that of ABŪ NAṢR (24) and that of IBN SĪNĀ, and felt aversion to the method of AL-AFḌAL-AL-KHAWINJĪ (25) and of ATHĪR AL-ABAHRĪ (26). I read with him a chapter of this " Book of Right Conduct " of IBN SĪNĀ; and he explained it in the best way. I read with him [in addition, works] about Medical Science. He wrote also on the Principles of Jurisprudence and on Applied Law, on the Arabic Language, Tradition, and Rhetoric, and on other subjects; but in these sciences he did not stand in the front rank but only contributed to them. He published, beside other works, a book in two volumes in which he explained the causes of the diversity in the mode of expression of scientists. But in this science he had only read the *Unmūdhaj* (" Model ") of AZ-ZAMAKHSHARĪ (27) and that with

Kulliyyāt (the general part of the *Canon* of AVICENNA) that he was called by his colleagues AL-KULLĪ (see IBN ABĪ UṢAIBI'A, II, 263). He lived from 1179-1276.

(23) This tract on Logic of AVICENNA has not come down to us.

(24) ABŪ NAṢR MUḤAMMAD AL-FĀRĀBĪ (d. 950 A. D.), AVICENNA's forerunner, the first great exponent of Aristotelian Logic in Arabic.

(25) AFḌAL AD-DĪN AL-KHAWINJĪ (1194-1248 A. D.) was a Persian medical man and philosopher, a judge in Cairo, and one of the teachers of IBN ABĪ UṢAIBI'A.

(26) ATHĪR AD-DĪN MUFAḌḌAL AL-ABAHRĪ (d. 1264 A. D.), philosopher and author of a much-famed Introduction to Logic.

(27) The grammar of one of the most famous Arabian philologists (d. 1143).

the Professor BAHĀ' AD-DĪN IBN AN-NAḤḤĀS; and yet he dared to write about that science.

Under him and under our Professor, 'IMĀD AD-DĪN AN-NĀBULUSĪ, the physicians in Egypt and Cairo studied. He was an Elder of tall stature with an oval face, slender, and of polite manners. I was told that during the illness of which he died, some physicians who were his friends, advised him to take some wine because, they maintained, his illness would be cured thereby. But he refused to take even a drop of it, and said: "I do not like to present myself before Allāh, the Most High, with wine in my body." He built a house for himself in Cairo and paved it with marble, even its hall, and I have never seen a marble hall save in this house. He was unmarried, and bequeathed this house and his books to the Manṣūrī Hospital (28). He did not think much of the style of expression of GALEN, and blamed it as being weak and tedious with nothing in it, and this in contrast to our Professor, 'IMAD AD-DĪN AN-NĀBULUSĪ, who valued him highly and encouraged the reading of the works of GALEN. 'ALĀ' AD-DĪN had been entrusted with the teaching of Jurisprudence at the Masrūriyya School in Cairo, and it is said that he explained in an excellent manner the *Tanbīh* (29) from the beginning to the chapter of *Sahw* (unmindfulness during prayer). He was ill for six days, at first on a Sunday, and died on the morning of Friday, the 21st of Dhu'l-Qa'da of the year 687 (30) in Cairo. May Allāh, the Most High, have mercy on him!

AṢ-ṢAFĪ ABU'L-FATḤ IBN YŪḤANNĀ IBN ṢALĪB IBN MURJĪ IBN MAUHŪB, the Christian (31), recited the following poem, which he composed himself and in which he laments 'ALĀ' AD-DĪN IBN AN-NAFĪS:

"Many a one asked: Is there still a scholar, or an excellent man, or a man of position and high qualities left after AL-'ALĀ'?"

"Then I answered, while fire was burning my heart: Stay! At AL-'ALĀ's death high qualities died with him!"

(28) Constructed in Cairo, 1281-4, by order of the Mamlūk Sultan AL-MANṢŪR QALĀWŪN.

(29) A well-known treatise on Muḥammadan Law by the celebrated jurist, ABŪ ISḤĀQ IBRĀHĪM OF SHĪRĀZ (in Persia), (d. 1287).

(30) This date corresponds to December 18th, 1288 A. D.

(31) An unknown scholar (or poet?).

End of the sayings of ATHĪR AD-DĪN.

The learned Imām, the Master BURHĀN AD-DĪN IBRĀHĪM AR-RASHĪDĪ, the preacher at the Mosque of Amīr Ḥusain in Cairo (32), told me the following:

If AL-'ALĀ' IBN AN-NAFĪS wanted to write, they laid the pens before him ready-cut; he turned his face towards the wall and began to write down his work without consulting a book; and he wrote like a down-pouring torrent. If the pen became blunt and used up, he threw it away and took another one so as not to lose time in pencutting.

I was told by the Master NAJM AD-DĪN AṢ-ṢAFADĪ (33)—Allāh, the Most High, have mercy on him!—:

The Professor BAHĀ' AD-DĪN IBN AN-NAḤḤĀS (34) used to say: "In Grammar I am not satisfied with anyone's style of expression in Cairo except that of 'ALĀ' AD-DĪN IBN AN-NAFĪS," or something like that. I have seen a small book written by him which he opposed to the book *Ḥayy ibn Yaqẓān* of IBN SĪNĀ (35) and which he designated the book *Fāḍil ibn Nāṭiq* (36). In it he defends the doctrines of Islām and their (the Moslems') views on the Prophecies, the Divine Laws, the Resurrection of the Body and the Transitoriness of the World. And—by my life!—he therein produced something wonderful and proving his ability, the acuteness of his perception and his capability in intellectual sciences.

I was told by AS-SADĪD AD-DUMJĀṬĪ, the doctor in Cairo (37) who was one of his pupils:

One night he and the QĀḌĪ (judge) JAMĀL AD-DĪN IBN WĀṢIL (38) were together whilst I was sleeping at their house. When they

(32) A shāfi'ite jurist, d. in Cairo, 1348 A. D.

(33) Another jurist, d. in Cairo, 1323 A. D.

(34) He was the teacher and predecessor of ATHĪR AD-DIN ABŪ ḤAYYĀN in Damascus; he died there in 1287, a year before IBN AN-NAFĪS.

(35) A philosophical and mystical allegory by AVICENNA. See BROCKELMANN, I, 455, and F. MEHREN, *Traités mystiques d'Abou Ali al-Hosain ibn Abdallāh ibn Sina*. Fasc. I (Leyde, 1889). Edition of the Arabic Text.

(36) This philosophical romance exists in a unique MS. in the Library of 'ASHIR EFENDI in Istanbul (I, 46, 1: by kindness of Dr. RITTER).

(37) A Jewish physician, d. 1339 A. D.

(38) A shāfi'ite jurist and a man of vast learning, born in Syria, d. in Cairo, 1299 A. D.

had ended the last evening prayer, they began a scientific discussion and passed from one science to another. Withal, the Master 'ALĀ' AD-DĪN conversed with self-control and without becoming heated; whereas the QĀḌĪ JAMĀL AD-DĪN became excited, his voice grew loud, his eyes glowed and the veins on his neck swelled. Thus they continued till dawn. On departing, the QĀḌĪ JAMĀL AD-DĪN said : " O Master 'ALĀ' AD-DĪN ! I am able to propose questions and subtleties and to establish rules; but you possess treasures of learning ! "

He said, moreover :

I told him : " My Master ! If you would write a commentary on *Ash-Shifā'* of IBN SĪNĀ (39) that would be better than the commentary on the *Qānūn* because people are in need of it." He then said : " I have met with some chapters in the *Shifā'* of which a rough copy is wanted." By this he meant that he did not fully understand those portions because the style of expression of the Chief *(Avicenna)* in the *Shifā'* is difficult.

Another told me :

The Master 'ALĀ' AD-DĪN once went to the public bath which is situated at BĀB AZ-ZUHŪMA (40). While he was washing himself, he went suddenly to the dressing-room *(maslakh)* of the bath, asked for ink, pens and paper and wrote down a treatise on the pulse from beginning to end. Thereupon he returned to the bath and finished his ablutions.

It is told that he once said : " If I did not know that my works will last for ten thousand years after me, I should not have written them." But the responsibility for this must be assumed by the man who related it about him. In sum, he was a great *Imām*, and many excellent men said : " He is a second IBN SĪNĀ."

The following I take from a biography in a book, the author of which I do not know :

He has written a commentary on the *Qānūn* in twenty volumes, in which he has elucidated its philosophical problems, drawn the logical parallels and explained its medical difficulties. No one previously had written such a commentary because the utmost of all previous commentators had been to content them-

(39) AVICENNA's great philosophical treatise, comprising Logic, Physics, Astronomy, Mathematics and Theology. See SARTON, vol. I, p. 710 et seq.

(40) One of the gates of Mediaeval Cairo.

selves with explanation of the *Kulliyāt* (41) up to the pulse of pregnant women, and in that part Medicine is rarely discussed. He also commented on all the books of the excellent HIPPOCRATES and indeed on most of them he wrote two commentaries, a detailed and an abbreviated one. He commented also on the *Ishārāt* (of AVICENNA) (42).

He knew the *Kulliyāt* of the *Qānūn* by heart and esteemed the style of HIPPOCRATES. He referred the students only to the *Qānūn* and he encouraged the people to read that book. He was always ready to give information by day or by night; to [seek] his company in his house came a number of Princes, as well as MUHADHDHIB AD-DĪN IBN ABĪ ḤALĪQA (43), the Chief of the Physicians, SHARAF AD-DĪN IBN SAGHĪR (44) and the great physicians; the persons were seated according to their rank. To his most excellent pupils belonged the Chief of the Physicians, BADR AD-DĪN ḤASAN (45), AMĪN AD-DAULA IBN AL-QUFF (46), AS-SADĪD ABU'L-FAḌL IBN KŪSHAK and ABU'L-FUṬŪḤ AL-ISKANDARĪ (47).

End.

Supplement to the Biography of IBN AN-NAFĪS from IBN FAḌLALLĀH AL 'UMARĪ's *Masālik al Abṣār* (Cairo Library *Mīm Ta'rīkh*,) No. 99, Vol. V, p. 149 et seq..

Several of them (his pupils), for example, our Master ABU'L-FATḤ AL-YA'MURĪ (48), told me the following: "IBN AN-NAFĪS possessed an enormous knowledge of [theoretical] Medicine and was initiated into its branches and principles. But he had not so much insight into the [practical] treatment. When he made prescriptions, he never departed from the method to which he

(41) Vide supra note 22.

(42) AVICENNA's main work on Logic.

(43) Perhaps a brother of RASHĪD AD-DĪN IBN ḤALĪQA, the most prominent pupil of AD-DAKHWĀR.

(44) A hitherto unknown physician.

(45) He is the afore-mentioned IBN QĀḌĪ BA'LABAKK (vide supra p. 104).

(46) He was also a pupil of IBN ABĪ UṢAIBI'A, lived from 1232-86 A. D., and is one of the rare Arabic scholars who wrote a treatise on Surgery.

(47) Both of them otherwise unknown Egyptian physicians.

(48) MUḤAMMAD AL-YA'MURĪ, a writer born in Seville, died in Cairo, 1334 A. D.

was accustomed; he did not prescribe any remedy so long as it was possible for him to prescribe a diet, and he did not prescribe compound remedies so long as he was able to make use of simple drugs. He prescribed farinaceous foods for sufferers from ulcers, blanquette for sufferers from vapours, carobs and parched chickpeas for sufferers from diarrhoea, and so on. In short, he prescribed for everyone the appropriate aliments, until the druggist, in whose shop he held his consultations (49) [grew angry and] told him one day : ' If you intend going on with prescriptions of this kind, you had better go and sit in a butcher's shop ! So long as you are with me, please prescribe sugar, syrup and remedies only ! ' "

Our Professor ABU'TH-THANĀ' AL-ḤALABĪ, the Secretary (50), told me the following : " I once complained to IBN AN-NAFĪS of a ganglion (51) on my wrist. He told me : ' By Allāh, I have myself got such a ganglion.' Thereupon I asked him : ' And what is the treatment for this affection ? ' He replied : ' By Allāh, I do not know myself how to treat it.' And after that he did not speak any more to me about this matter." Here ends the great biography.

The other seven biographies are much shorter and give only extracts from the foregoing long biography. The only notable addition is to be found in the " History of Islām " by ABŪ 'ABDALLĀH MUḤAMMAD IBN AḤMAD ADH-DHAHABĪ, a shāfi'ite jurist and historian (d. in Cairo 1348 A. D.) (52). He mentions the fact that IBN AN-NAFĪS was appointed Chief of the Physicians in Egypt *(Ra'īs al-Aṭibbā' fī Miṣr)*, but he does not tell us at what period and by what Sultan of Egypt. He also says that IBN AN-NAFĪS reached the age of eighty. As the Muḥammadan (lunar) year is 11 days shorter than the solar year, IBN AN-NAFĪS must have lived from about 1210 to 1288 A. D.

I may add that I had an opportunity of seeing IBN AN-NAFĪS' own handwriting, by the kindness of Dr. A. S. YAHUDA in London,

(49) It was, and still is sometimes, the habit of Oriental doctors to hold their consultations in drug-stores.

(50) SHIHĀB AD-DĪN MAḤMŪD (1246-1325), historian and philologist (BROCKELM., II, p. 44 and p. 55).

(51) The Arabic term *'uqqāl* means a shackle or tether; medically its meaning is probably a ganglion or another affection of the articulations hindering free movement.

(52) MS. *Ta'rīkh No.* 42, Cairo Egyptian Library.

in an old and valuable copy of IBN AN-NAFĪS' Commentary on HIPPOCRATES' *De Natura Hominis*. At the end of this volume IBN AN-NAFĪS certifies, in an autograph note, to one of his pupils, ABU'L-FAḌL—probably Kūshak who is mentioned on page 110—that his copy has been taken from the original MS., and that he had discussed its contents from beginning to end with ABU'L-FAḌL.

IBN AN-NAFĪS was one of the prominent physicians of that late-flourishing period of the hospitals in Syria and Egypt at the time when Baghdad was being destroyed by the Mongols (in 1258 A. D.) and when the decline of Medicine and Philosophy had begun in Spain. He was, in general, not an original thinker, but a learned commentator. In any case, he surpasses his countrymen by his more critical spirit, the most impressive proof of which is his ideas on the Lesser Circulation which we shall translate in part below. In him, moreover, as in many of his contemporaries, the spirit of Greek Learning, Philosophy and Medicine, in particular the Galenic System, is strongly alive, and the vastness of his erudition is remarkable.

D. — A SHORT REVIEW OF IBN AN-NAFĪS' WORKS.

We shall speak mainly of his medical output, of which several works have come down to us. He himself composed three original books:

1. "The Comprehensive Book on Medicine" *(Kitāb ash-Shāmil fi'ṭ-Ṭibb)*. According to the note given in the foregoing biography, it must have been an enormously bulky encyclopaedia, but it was never finished. There are now no relics of it in Oriental libraries, although it still existed in MS. in Cairo about 1350 A. D.

2. "The Well-Arranged Book on Ophthalmology" *(Kitāb al-Muhadhdhab fi'l-Kuḥl)*. This work is also lost and is only known to us by certain quotations by later oculists.

3. "The Choice of Aliments" *(Kitāb al Mukhtār min al-Aghdhiya)*. This work exists in a MS. in the Berlin State Library (Catalogue AHLWARDT 615 f.). It seems to be a compilation of little value.

More numerous and important are IBN AN-NAFĪS' commentaries on different medical works of Greek and Islamic physicians. Among them is a commentary on HIPPOCRATES' Aphorisms, one on his Prognostics, one on his Epidemics, all in existence in Public libraries (53), and one on his *De Natura Hominis*, in the possession of Dr. A. S. YAHUDA (London). That on the Aphorisms has been printed, in Persia, in a lithographic edition without mention of place or date, but it was probably printed about 1875. There is also a Commentary on GALEN's Anatomy, but the authorship of this is uncertain.

A commentary on the famous *Questions on Medicine* of ḤUNAIN IBN ISḤĀQ (54) is preserved in a MS. copy at Leyden (no. 1296).

A commentary on the whole *Canon* of IBN SĪNĀ (AVICENNA); large parts of this important work are now in the British Museum Library in London.

A commentary on IBN SĪNĀ's Anatomy; this is the book of which we shall have to treat later on.

The book by IBN AN-NAFĪS which met with the greatest success in the Oriental medical world was his "*Abstract (Epitome) of* AVICENNA*'s Canon*" *(Mūjiz al Qānūn)*. It exists in innumerable MS. copies and has been published in print at least six times in India between 1828 and 1906. It was also the subject of a series of commentaries and super-commentaries, of which the most reputed is that by NAFĪS IBN 'IWAḌ, a Persian physician of the XVth cent. A. D. (55).

We shall not make detailed mention here of IBN AN-NAFĪS' theological, philological, juridical and philosophical works; several of them are recorded in the biography translated above. Very little of this scientific output has survived. The philosophical romance, *Fāḍil ibn Nāṭiq*, is one of the few remainders (56).

(53) See BROCKELM., I, 493.

(54) See SARTON, I, 611.

(55) See SARTON's extensive bibliography (II, 1101 f.). This commentary has also been printed in Persia and India.

(56) Vide supra note 36.

E. — Ibn an-Nafīs' Commentary on Ibn Sīnā's Anatomy.

The work with which our present investigation is concerned, is the "Commentary on the Anatomy in the *Canon* of Ibn Sīnā" *(Sharḥ Tashriḥ al-Qānūn li-'bn Sīnā)*. We do not know at what time of his life Ibn an-Nafīs wrote this book, but it is most likely to have been about the middle of the XIIIth century of our era. It is a voluminous work, comprising a commentary on the first five sections of Book I of Avicenna's *Canon (al-Kulliyyāt)*, and, in addition, a commentary on the anatomical sections which are scattered through Book III of the same work. In this way Ibn an-Nafīs has commented on the whole of the anatomical sections of the *Canon*, as Avicenna never wrote a special treatise on Anatomy. It may be mentioned, in passing, that De Koning, when he translated Ibn Sīnā's Anatomy, was obliged to adopt the same method (57).

There are several MSS. of this Commentary in existence —according to Brockelmann (I, 457) four, but their number may be much greater. I used for my edition and translation of some short selected extracts the two Berlin MSS. catalogued by Ahlwardt (58) under No. 6272. One of them (*Mf.* 912) was made use of by aṭ-Ṭaṭāwī; the other (*Landberg* 931) is very old and was copied in 730 A. H. (i. e. 1330 A. D.), or forty-two years after the death of Ibn an-Nafīs. I utilised mainly this latter MS. which presents more difficulty to the reader because it is sparingly punctuated and more closely written than others. Precious help was given me, however, by a modern but very good MS. which I was able to purchase from Persia in January, 1933. This copy, written by a Persian physician in 1844, contains on pp. 257-785 the entire commentary in clear script and with many corrections by collation with another MS., the whole showing itself to be the work of a careful and competent medical scholar.

The edition of text and translation was very much facilitated by the unselfish help of my friend, Professor Joseph Schacht

(57) P. de Koning, *Trois traités d'anatomie arabes*, etc. Leide, 1903.
(58) W. Ahlwardt, p. 538 et seq.

(of Königsberg, Germany), to whom I am very much indebted. I give in the following pages only a part of all the sections that we translated, those which show the fundamental idea of IBN AN-NAFĪS as well as his manner of reasoning.

I. — *From the Author's Preface.*

(MS. Berlin, *Landberg 931* fol., 1 v.).

In the Name of Allāh, the Charitable and Merciful !

The excellent Master, the most learned 'ALĀ' AD-DĪN ABU'L-ḤASAN 'ALĪ IBN ABI'L-ḤAZM AL-QURASHĪ, says :

" After due praise of Allāh and prayer for his prophets and emissaries—it is at present our aim to examine according to our ability the sayings of the Master and Chief ABŪ 'ALĪ AL-ḤUSAIN IBN 'ABDALLĀH IBN SĪNĀ—may Allāh have mercy on him !—concerning the Anatomy of the entire book of the *Canon*. We proceed thus, that we join his sayings in the first Book of the *Canon* to his sayings in the third Book, and this in order to have the explanation of the entire Anatomy collected and coordinated. *The interdiction of the Religious Law and our own natural Charity have prevented us from practical dissection.* We intend, therefore, to rely when studying the form of the internal organs, on the explanations of those who were able, before our time, to practise this, particularly on those of the excellent GALEN, as his books are the best that have come down to us concerning this art. He has, besides other things, observed many muscles which had never before been perceived. Therefore we rely in scrutinizing the form and situation of the organs and so on, mostly on his words, except in some few [erroneous] opinions where we suppose that they were caused by mistakes of the copyists or that his sayings were not based on careful consideration..

" After this, we intend composing an Introduction in which we shall determine the exact knowledge of this art (Anatomy)..."

Then follow five introductory chapters dealing with the difference in the anatomical form of the organs of animals, the utility of the science of Anatomy, the functions of organs and their discovery by the aid of Anatomy. In the fifth chapter, some practical hints on Dissection are given on the lines of GALEN's *Anatomicae Administrationes*, Book I.

II. — *Anatomy of the Pulmonary Vessels.* IBN AN-NAFĪS records and comments AVICENNA's sayings, and then continues (*fol.* 46 *r.*):

" We say, however—Allāh knows better—: As the production of the [vital] spirit is one of the functions of the heart, and as this spirit consists of much-refined blood with a large admixture of airy substance, it is necessary that the heart should contain both refined blood and air so that the spirit may be generated out of the substance produced by their mixture; this takes place where the spirit is generated, viz. in the left cavity of the heart. It is, moreover, indispensable for the heart of man and of such animals as have lungs like him, to possess another cavity in which the blood is refined in order to become apt for the mixture with the air; for, if air is mixed with thick blood, it is not possible to form a homogeneous substance out of them. This cavity is the right cavity of the heart. The blood, after it has been refined in this cavity, must be transmitted to the left cavity where the [vital] spirit is generated. ***But there is no passage between these two cavities;*** for the substance of the heart is solid in this region and has neither a visible passage, as was thought by some persons, nor an invisible one which could have permitted the transmission of blood, as was alleged by GALEN. The pores of the heart there are closed and its substance is thick. Therefore, ***the blood***, after having been refined, ***must rise in the arterious vein to the lung in order to expand in its volume and to be mixed with air*** so that its finest part may be clarified ***and may reach the venous artery in which it is transmitted to the left cavity of the heart.*** This, after having been mixed with the air and having attained the aptitude to generate the [vital] spirit. That part [of the blood] which is less refined, is used by the lung for its nutrition.

For this reason the arterious vein has solid substance with two layers, in order to make more refined that (the blood) which transsudes from it. The venous artery, on the other hand, has thin substance in order to facilitate the reception of the transsuded [blood] from the vein in question. And for the same reason there exist perceptible passages (or pores, *manāfidh*) between the two [blood-vessels]."

In the following section (*fol.* 46 *v.* of the MS.), IBN AN-NAFĪS

treats of the " venous artery " (pulmonary vein) and the aorta, and explains that the former is smaller than the latter because the vein contains only a little blood while the aorta contains the same amount of blood mixed with much airy matter, i. e. the " vital spirit " for the whole body.

On *fol.* 50 *r.*, the Author repeats the explanation of the thick wall of the pulmonary artery, which has very close pores " so that only very refined blood may transsude from it; this blood filtered through finds the great quantity of air distributed in the cells of the lung and is mixed with it in order to acquire the aptitude to generate the vital spirit."

On *fols.* 63 *v.*-65 *r.*, IBN AN-NAFĪS speaks of the anatomy of lung and heart, and there he repeats in four different places the new physiological explanation and the cause of the heart having its peculiar shape. He explains it quite in the teleological manner of GALEN.

On *fol.* 65 *r.* and *v.*, he then repeats this a last time, while he refutes AVICENNA's saying ***that the heart has three ventricles***. In this, AVICENNA did not follow GALEN but ARISTOTLE, who thought that the number of ventricles varied according to the size of the animal. IBN AN-NAFĪS says: " This opinion is not correct; the heart has two ventricles only. One of them is filled with blood—that it the right; and the other with [vital] spirit—that is the left. ***There is no passage at all between these two ventricles;*** if there were, the blood would penetrate to the place of the spirit and spoil its substance. Anatomy refutes the contentions [of former authors]; on the contrary, the *septum* between the two ventricles is of thicker substance than other parts in order to prevent the passage of blood or spirit which might be harmful. Therefore the contention of some persons who say that this place is porous, is erroneous; it is based on the preconceived idea that the blood from the right ventricle had to pass through this porosity—and they are wrong! For the penetration of the blood into the left ventricle is from the lung, after it has been heated within the right ventricle and risen from it, as we stated before."

At the end of his anatomical considerations regarding the heart, IBN AN-NAFĪS contends that the right ventricle has no active movement and that it is unimportant whether one designates the heart as a muscle or not.

Conclusion.

I think that the foregoing few passages already provide the proof of Dr. aṭ-Ṭaṭāwī's claim that Ibn an-Nafīs propounded the theory of the pulmonary circulation three centuries before Michael Servetus. We must not forget, however, that, according to Neuburger (59), in reality no detached knowledge of the pulmonary circulation can be allowed him, as Ibn an-Nafīs—and probably also Servetus—did not accept the passage of the *entire* volume of the blood through the lungs, and as both of them still strongly adhered to the antique theory of the " vital spirit " filling the arteries and to that of the centrifugal movement of the blood in the veins. Ibn an-Nafīs based, as he says himself, his commentary and also his new theory, not on dissections of dead human bodies or living animals but on theoretical considerations only. In many places in his Commentary he gives wrong opinions; if he is nearly right in his theory of the lesser circulation, he must submit to the judgment which Bowie (60) passed on the discoveries of Servetus :

" ... the only credit due to him is that of having made a very happy guess, but one which did not advance the explanation further." Ibn an-Nafīs did not mention his theory in his other works, as far as I was able to study them; and no other Islamic author after him spoke of this astonishing theory which challenges Galen and Avicenna, the overwhelming authorities of Mediaeval Medicine. It is, however, possible that there will be found some traces of Ibn an-Nafīs' sayings in some of the many unpublished medical MSS. of his friends and pupils which lie in Oriental libraries. The foremost medical authorities of the later centuries of Islam (e. g. as-Suwaidī, Dāwūd al-Anṭākī, etc.) are silent. As Ibn an-Nafīs' works have not been translated into Latin, except one of his Commentaries (61), it is improbable that he exercised any influence on European medical thought.

(59) Max Neuburger, *Zur Entdeckungsgeschichte des Lungenkreislaufs*. Sudhoffs Archiv f. Geschichte der Medizin, XXIII (1930), pp. 7-9.

(60) *On the Motion of the Heart and Blood in Animals*. By William Harvey..., ed. Alexander Bowie. London, 1889, p. XVI.

(61) *Ebenefis philosophi ac medici expositio super quintum canonem Avicennae*

It is all the more curious to observe that SERVETUS' famous passage on the circulation of the blood is very similar to certain passages in IBN AN-NAFĪS' commentary. It reads as if it were an extract made from the latter's work. It is known that MICHAEL SERVETUS, theologian and physician, inserted in his great theological work *Christianismi Restitutio* a medical argument in order to prove the accurateness of the Biblical dictum that *the soul is in the blood*. His book appeared in 1553, provoked a great uproar among the Catholic and Calvinist clergy and caused the author to be imprisoned and burned alive, his book being burned with him, in October, 1553, at Geneva. Copies of the book and its reprint are extremely rare, and its contents are forgotten, with the exception of the passage on the blood which has been frequently quoted. The most important part of it reads as follows :

Generatur (spiritus) ex facta in pulmonibus commixtione inspirati aëris cum elaborato subtili sanguine, quem dexter ventriculus sinistro communicat. Fit autem communicatio haec, ne per parietem cordis medium, ut vulgo creditur, sed magno artifitio a dextro cordis ventriculo, longo per pulmones ductu, agitatur sanguis subtilis; a pulmonibus praeparatur, flavus efficitur et a vena arteriosa in arteriam venosam transfunditur. Deinde in ipsa arteria venosa inspirato aëre miscetur et expiratione a fuligine repurgatur. Atque ita tandem a sinistro cordis ventriculo totum mixtum per diastolem attrahitur, apta supellex ut fiat spiritus vitalis. Quod ita per pulmones fiat communicatio et praeparatio, docet conjunctio varia at communicatio venae arteriosae cum arteria venosa in pulmonibus. Confirmat hoc magnitudo insignis venae arteriosae quae nec talis nec tanta facta esset... ob solum eorum [pulmonum] nutrimentum.

I thought at first that SERVETUS might have obtained some knowledge of IBN AN-NAFĪS' book through one of the few Mozarabs which existed in Spain about 1500, at the time of SERVETUS' birth and early education. But the recent critical biography of SERVETUS by GOYANES (62) proves that the Spaniard

ab Andrea Alpago Bellunensi ex arabico in latimum versa. Venice, 1547. See SARTON, II, p. 1100.

(62) J. GOYANES, *Miguel Serveto, teologo, geografo y medico*, etc., Madrid, 1933, p. 147 et seq. See also Sir WILLIAM OSLER's article on MICHAEL SERVETUS. (The Johns Hopkins Hospital Bulletin, vol. XXI, 1910, pp. 1-11).

did not begin his medical studies much earlier than 1536, in Paris where he studied Anatomy and made dissections under the guidance of JOHANNES GÜNTHER (GUINTERIUS ANDERNACUS)—we remark, in passing, that his fellow-students included AMBROISE PARÉ and ANDRÉ VÉSALE. As SERVETUS never returned to Spain, I do not see any possibility for him to have obtained knowledge of IBN AN-NAFĪS' writings. And so I think he made his discovery quite alone and independently of the Arabic author. The same thing is certain concerning REALDO COLOMBO, who published his ideas on the Lesser Circulation six years after SERVETUS, in his *De Re Anatomica* (Padua, 1559). Neither of them realized the full implications of their discovery, which was extended in the course of the XVIth century by FABRICIUS' description of the venous valves and by CESALPINUS' increasingly clear insight into the mechanism of circulation of the blood (63). It was and still remains the undying honour of WILLIAM HARVEY to have proved the entire system of circulation; the conclusive experimental proof was given by him, not in his famous book in 1628, but only in 1651, when he wrote to a German practitioner in Hamburg telling him that he had succeeded in propelling water from the pulmonary artery to the pulmonary veins in bodies. It is now certain that the first of his precursors was IBN AN-NAFĪS, who based his discovery on pure scientific speculation, forbidden as he was the opportunity of making dissections even on animals.

Cairo. MAX MEYERHOF.

(63) See the recent survey of the question by P. CAPPARONI, *La storia della scoperta della circolazione del sangue.* Siena, 1932.

An Anglo-Norman Algorism of the Fourteenth Century

Introduction

During a sabbatical leave from the University of Michigan in 1926 to 1927 the writer continued in Europe a work begun by correspondence to locate in European libraries early manuscript arithmetics in the vernacular. At Oxford was found a thirteenth century algorism (1) in French much more complete and of greater importance than the only French algorism (2) then available in print. At Brussels was found a French algorism (3) of the fifteenth century. At Paris a Provençal arithmetic, probably of the late fifteenth century, was located. In Florence the earliest known arithmetic in Italian (4) was found.

It was my good fortune to interest in the early French arithmetics the late Professor E. G. R. Waters, Professor of Romance Languages at Oxford, who published, as indicated in the foot-notes above, the text of the first two mentioned algorisms. Professor Waters prepared also for a proposed Corpus of French Algorisms the translation and notes on the first three sections of the Provençal algorism. Since the untimely death of Professor

(1) E. G. R. Waters, A Thirteenth Century Algorism in French Verse, with Introduction by Louis C. Karpinski, *Isis*, No. 35, Vol. XI, pp. 45-84.

(2) Charles Henry, Sur les deux plus anciens traités français d'algorisme et de géométrie, *Bullettino di bibl. e di storia delle scienze mat. e fisiche*, Vol. XV, pp. 49-70. The algorism text occupies only some two pages. Victor Mortet, Le plus ancien traité français d'algorisme, *Bibl. Math.*, 3d Series, Vol. 9, pp. 55-64.

(3) E. G. R. Waters, A Fifteenth Century French Algorism from Liége, *Isis*, No. 38, Vol. XII, pp. 194-236. With two plates.

(4) Louis C. Karpinski, The Italian Arithmetic and Algebra of Master Jacob of Florence, 1307, *Archivio di Storia della Scienza, Archeion*, Vol. XI (1929), pp. 170-177.

WATERS in 1930, work on the remainder of that algorism is being continued by Professor E. L. ADAMS of the University of Michigan and myself (5).

Since 1926-1927 the writer has further located at Corpus Christi College in Cambridge a French algorism of the fourteenth century, Ms. 133, briefly described by M. R. JAMES in his Catalogue of the Corpus Christi College Manuscripts, which is the subject of the article by Mr. STAUBACH. Some other fragments of French mathematical works were located with the aid of Dr. DOROTHY WALEY SINGER's bibliographical material on scientific manuscripts in English libraries, courteously loaned to me for the purpose of my study.

This algorism occupies the first two leaves and the recto of the third, double columns, of the manuscript containing the important *Scala Chronica* by THOMAS GRAY of Oxford, begun in the year 1355. We are indebted to the authorities of Corpus Christi College for permission to secure rotographs of the manuscript. I am further indebted to the Master of the College for the opportunity in September of 1933 to examine the manuscript itself and thus to correct several readings obscure due to folds in the vellum. There seems to be little doubt that the algorism was prepared about the same time as the *Scala Chronica* since the two leaves of the algorism constitue an integral part of the first quire of vellum leaves while the handwriting and the vocabulary are entirely similar to that employed in the Chronicle.

It is worthy of note that the important collection of manuscripts in the Corpus Christi College Library was constituted largely by the collection bequeathed to the College in 1574 by Archbishop MATTHEW PARKER. These manuscripts originated quite certainly from the English monastic libraries but the provenance of this manuscript has not been established. The fact that the manu-

(5) LOUIS C. KARPINSKI, Early Algorisms in French, (Bologna, 1931), pp. 455-458, in the report of the International Congress of Mathematics held at Bologna in 1931. Mention should also be made of two French arithmetics of the end of the fifteenth century: LYNN THORNDIKE, The Arithmetic of Jehan Adam, *Amer. Math. Monthly*, Vol. XXXIII, 1926, pp. 24-28. ARISTIDE MARRE, Notice sur Nicolas Chuquet et son Triparty en la science des nombres, *Bullettino di Bibl. e di Storia d. Scienze Mat. e Fis.*, Vol. XIII, pp. 555-659, Appendice au Triparty..., Vol. XIV, pp. 413-460.

script was probably written in England is indicated not only by the authorship of the Chronicle, but also by the fact that five lines in English appear at the end of the algorism and also that additional verses in French after the end of the algorism refer to English measures.

So far as the importance and significance of this text is concerned, the first point to be noted is that this document completes a chronological sequence with the two French algorisms published by Professor WATERS. The outstanding importance of the early French translations in science has been shown very clearly by Dr. SARTON in his *Introduction to the History of Science* (6). It is fortunate to have for French arithmetic so complete a series of these documents as the three now available in *Isis*, together with the one published by VICTOR MORTET and M. CHARLES HENRY, as noted above.

The text of this algorism reveals remarkably close adherence to the ideas and even the terminology of the other French algorisms heretofore published. In the number of fundamental operations, six, this algorism follows the two twelfth century algorisms (7) which were published with English translation. However, in substraction the French algorisms all mention that intervening zeros are changed to nines while twelfth century Latin above does not.

There are several minor differences hardly worth any discussion. However, the representation of the extra half when an odd number is divided by two gives rise to noteworthy differences. In our algorism and in the Liége fifteenth century there is the idea of a zero with a line through or above it to represent the extra half; in the Oxford manuscript two lines of text seem to be left out at this point, apparently not understood by the scribe. This zero with a line above it actually appears in apparently contemporary hand in the margin of our manuscript. The reference to a " strik " possibly corresponds to a reference in SACROBOSCO's Algorismus vulgaris to the " figure for one-half."

Considering the difficulties in attempting to put rules concerning new forms of fundamental arithmetical operations, into

(6) Vol. II, pp. 530-531, 540-541, 803, 815-816.

(7) LOUIS C. KARPINSKI, Two Twelfth Century Algorisms, *Isis*, Vol. III, pp. 396-413.

verse when the material itself was not too well understood, one can only express admiration for the achievement of the unknown poet-mathematician. Certainly this document rendered real service in making available to a larger audience the mysteries of the new Hindu-Arabic arithmetic.

Ann Arbor, Mich. LOUIS C. KARPINSKI.

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I. — THE MANUSCRIPT

§ 1. The text of the Algorism occupies the first four pages of the manuscript, from folio 1 v° through folio 3 r°. It consists of 275 lines (line 1, unrimed, giving the ten Arabic numerals), followed by two lines of *Explicit;* after this there are five short miscellanea, all on folio 3 r°. There are two columns of verse to a page, running slightly over 40 lines to a column. The handwriting is quite legible on the whole. The principal difficulty in transcription arose from the deep crease in the lower half of col. b, folio 1 v°. The readings for this portion, as well as for several places where poor lighting makes the rotograph indistinct, were assured by Professor KARPINSKI by an examination of the original manuscript.

§ 2. The abbreviations are for the most part normal Old French abbreviations. Italics are used to indicate the expansions. For *figure* and *articulus* see below, IV, § 4. Otherwise, no problem of importance arose from the abbreviations.

§ 3. Professor KARPINSKI has pointed out in the introduction that the Ms. must be contemporary with the *Scala Chronica*, found in the same volume. There is no internal evidence, beyond the emblem, crown 78 (see III, § 3) as to either date or author. There is some linguistic evidence that the text was composed at about the time of this redaction (V, § 2). It seems probable that the scribe was translating from one of the many Latin algorisms that were current at that time, despite the parallels cited by Professor KARPINSKI to other known French algorisms. There are no word for word parallels, and certain differences of arrangement make it very doubtful that the scribe was copying

a French text. He seemed not to know the terms *digit*, *compost*, and *article*, used in the St. Genevieve text (8) nor the forms *doi*, *compot*, *article*, found in the XIIIth century text published by WATERS (9); but preferred the full Latin forms, *digitus*, *articulus*, *compositus* (see VI, § 3). The only reference in the algorism to a source is indefinite : si dist le liure, line 252. The text is in the Anglo-Norman dialect (see IV, V).

II. — CONTENTS

The algorism consists of 137 rimed couplets, mostly octosyllabic, preceded by one unrimed line as above noted. Despite a few confusing passages, notably lines 253-254, there are no good grounds for supposing any lacunae. The following divisions of subject matter are indicated by paragraph marks in the margin :

1. 1- 40; Statement of the value of numbers in their various positions; definition of digit, article, and composite.
2. 40- 52; The manner of writing digit, article, and composite.
3. 53- 61; Statement of the six fundamental operations.
4. 62- 93: Addition.
5. 94-119; Subtraction.
6. 120-125; Doubling.
7. 126-159; Halving.
8. 160-215; Multiplication.
9. 216-275; Division.

Square root and cube root, which are treated in the two earlier French algorisms, are not touched on here (see introduction).

In two places (lines 60 and 254) the abbreviation *no*[*ta*] calls attention to a peculiar line. Some of the operations are illustrated numerically in the margin; these annotations are largely illegible, some due to lack of clarity in the rotograph, as in col. b, folio 1 v° and col. b, folio 2 v°; others are bound in, as in col. a, folio 2 r°.

Opposite line 141, an unhalved one is indicated by the figure

(8) MORTET VICTOR, Le plus ancien traité français d'algorism, in *Bibl. Math.*, Vol. 9, Ser. 3, pp. 55-64.

(9) E. G. R. WATERS, A Thirteenth Century Algorism in French verse, in *Isis*, Vol. XI, pp. 49-84.

one with a mark over it. Four lines below, the sign for $\frac{1}{2}$ is given : a zero with a mark over it. Opposite lines 162-164 is the set-up for multiplication : 359 times 42. In col. a, folio 2 v° further steps in multiplication are shown.

At the bottom of folio 1 v° there is an annotation in a cursive hand. Unfortunately this is largely illegible, due to the light on the rotograph, and I have not been able to transcribe it.

This text affords an important addition to the available scientific material in Old French. It is of interest to the literary student as well as to the historian of science, because it shows, together with the like works cited by Prof. KARPINSKI, the formulation of a practical spirit in the midst of the legendary bestiaries, the visionary computs and calendars, the divination books, and other less realistic didactic literature which was current. However, its poetic merit is not great. The style is matter of fact, and the versification has all the looseness of the later Anglo-Norman poetry. In this respect, it is perhaps excelled by the two Old French algorisms published by WATERS.

III. — THE MISCELLANEA

§ 1. Lines 277-288 consist of four rimed couplets and four lines rimed alternately. Lines 281, 282, and 288 are definitely short, in other lines hiatus or elision must be allowed. This passage is concerned with English measures of length, discussed below (§ 4) in connection with a similar passage in English.

The 13th C. Latin Ms. described by STEELE (9^{bis}) (Bibl. Nath. Lat. 16089) contains on *fol.* 91 v° a short passage on measures. However, it skips directly from grains to feet, associates the pace with ***milites antiguos***, then goes off into a discussion of angles and perpendiculars. We cannot see too close an anology with our text.

§ 2. Lines 289-300 consist likewise of four rimed couplets and four lines rimed alternately. The majority of these lines are long. The section discusses English (or Anglo-Norman) measures of area. The acre here defined seems to contain 160 square ***perches***, the largest acre known to the Old French

(9^{bis}) ROBERT STEELE, Roger Bacon as Professor, in *Isis*, vol. XX n°, 58. (Nov., 1933), p. 53.

dictionaries. Of those consulted (10), only the *Dictionnaire Historique* of the *Académie Française* records as large an acre : *Chascune acre contient wit vinz perches.* (Charte de 1308.) This corresponds to the modern acre of 160 square rods, except that the *perche* is 18 feet, the modern rod, 16 1/2 feet.

§ 3. Lines 301-304 : Four lines, rimed alternately. The first lines are perfect octosyllables, the fourth may or may not be depending on the pronunciation of the numeral 78. The passage is a sort of *envoi*, and is the only passage of the entire 328 lines which has any poetic merit. The symbolism of the crowned 78 raises a question. In the margin is a crown, with this number written below it. The solution of this symbol might offer some clew as to the authorship and date of the work.

§ 4. Lines 305-309 are in English, rather clumsily rimed. The first three lines correspond with lines 281-282 above, concerning the number of feet in a pace, and the number of paces in a *lue*, or *forlong*. The mile is given as of eight *forlongs*, that is, 5000 feet; two miles equal a *lencke*. However, the text in French, (§ 1, above) corresponds only as far as the pace. 125 *pas* make a *lue*, which corresponds to the *forlong*. Apparently, two *lues* make a French *lencke*, that is, 1250 *pees* as opposed to 10,000 feet by the English calculation. However, it may be that the author has taken *lue* in two senses. I have suggested in the translation a possible reading that would remove the apparent contradiction of these two sections (11).

§ 5. Lines 310-328 : The first four lines are rimed; if intended to be octosyllabes, they are imperfect. The remainder of the passage is in prose. Lines 310-313 paraphrase lines 60-61 of the algorism. The prose portion is a gloss on lines 12-25, concerning the value of a figure according to its position. Nothing essential to the comprehension of the algorism is added, though apparently the scribe's intention was to clarify the rimed version.

IV. — Versification

§ 1. In checking the metrical system of this text, I arbitrarily

(10) See Vocabulary.
(11) Also, see Vocabulary, *lue* and *lencke*.

considered as the norm the following : 1° hiatus between words ending and beginning, respectively, with a vowel; 2° *u* or *i* with *a*, *o*, or *e* within a word, makes one syllable, whether originally a diphthong or not; 3° neutral *e* at the end of the line does not count in the eight syllables. The only virtue I claim for this procedure is that it gave a point of departure.

In spite of the attempt made to analyse the metrics, or rather as a result of that attempt, the following observations by JOHAN VISING (12) must be considered as applying here : 1° the pronunciation of atonic *e*, hiatus,and elision, are uncertain; 2° in the later period, the poet was often satisfied if he wrote lines of approximately the same length; 3° neutral final *e* in the rime word frequently counted as the eighth syllable (see § 7, below); 4° hence, application of French rules of hiatus and elision is of little force, where the value of neutral *e* is uncertain. VISING allows the possibility of such hiatus as *de els*, *de autre*, etc. (see § 6, below); 5° rimes such as *moster : pere* are to be allowed (see § 2, below).

§ 2. The rimes are on the whole normal Old French rimes. There are thirty feminine couplets, and eight which are mixed. The latter cases serve to indicate (as more completely shown below) that the author had no strong feeling for or against the final neutral *e*. These couplets are 34-35; 102-103; 140-141; 166-167; 202-203; 208-209; 238-239; 260-261. Such rimes are considered normal in Anglo-Norman (13). Two successive couplets have the same rime in 10-13; 164-167; three successive couplets have the same rime in 54-59. In four couplets the rime is reduced to assonance : 84-85; 90-91; 144-145; 244-245; also perhaps 158-159 (see V, § 2, 1, below); 86-87. A paragogical *e* occurs in *significationne* 28 to rime with *donne* (Ms. *donnez*), 29; in *appresse*, 47, to rime with *dresse*, 46. Five false rimes offer difficulties : 52-53; 138-139; 160-161 (cf. 164-165); 200-201; 196-197. Nine cases illustrate that final *z* frequently has the value of *s* : 6-7; 60-61; 16-17; 108-109; 34-35; 246-247; 254-255; 100-101; 90-91 (see VI, § 1; § 10).

(12) *Anglo-Norman Language and Literature*, London, Oxford Univ. Press, 1923. *Language and Literature Series*, pp. 79-86. This book is a most useful summary and survey of the field.

(13) VISING, *op. cit.*, p. 86.

§ 3. *Neutral e within the line.* A marked Anglo-Norman characteristic of this text is the discounting of final neutral *e* within the line, even when before a word beginning with a consonant (14). The clearest case is that of the word *figure* (abbreviated *fig*^{ar} in every case). In only two clear cases is it given the full three syllable count (198, 200); also possibly in 107, 213, 248. The neutral *e* is discounted before a consonant in 8, 29, 66, 91, 108, 122, 128, 134?, 230, 241, 243, and seems to be elided in 15, 159. In the plural, *figures* (written in full in 4; abbreviated *fig*^{ar}*s* elsewhere) counts as two syllables in 71, 93, 119, 184, 237; as three syllables only in 239. The neutral *e* is discounted in *nombre*, 30, 111, 168, 242, 274; *nombre*[*s*] (Ms. *nombrez*), 212; *nombres*, 218; *cifre*, 11?, 25, 105, 153, 192, 209; *cifres*, 114; *garde*, 130, 234; *altre*, 159, 186; *signe*, 140; *lyne*, 127?; *lynes*, 96; *amonte*, 207; *graindre*, 219; *nonnes*, 31; there are four double cases: *cifre... primes*, 47 and 79; *darraine... darraine*, 244; *meisme... nombre*, 214. Note also the feminine forms *un* (VI, § 4), *el*, *els* (VI, § 8). The neutral *e* is counted, however, in about an equal number of cases: *nombre*, 41, 163, 173, 185, 193, 261, 272; *nombres*, 43; *cifre*, 26, 87, 89, 116, 145, 204, 206; *garde*, 80; cf. also *graindre*, 98, *maindre*, 99, which are in rime.

§ 4. *Abbreviations counted as written.* Doubt is thrown on the count of 2nd person plural endings, as in 66, 71, or on counting of elision or hiatus, or discounted neutral *e*, as in 149, 155, by the author's tendency to count abbreviations as written. This is clearly shown by lines 60 and 61: *add. subt. medi.* = 4 syllables; *du. di. multi.* = 4 syllables; also by line 78, where the abbreviation *less.* serves not only to make the syllable count, but also to rime with *apres*, 79. The author's favorite, however, is *fig*^{ar}, which counts as one syllable in 103, 149, 155, 164, 183, 202, 207, 228, 251; and *fig*^{ar}*s*, one syllable in 178, 247.

Articulus is a close second to *figure*. It is regularly abbreviated *articls*. The barred *l* stands for *ul* (cf. forms of *mltiplier* in 176, 177, etc.), but the long hooked *s*, indicating *us*, is never used with this word. Articulus is rimed with *compositus*, 38-38; with *digitus*, 76-77; and is once written articulus, 51. Hence, it seems necessary to transcribe always the four syllable form.

(14) VISING, *op. cit.*, p. 79. I have given full references for this phenomenon, as it seems to have been left an open question by students of the dialect.

Like *figure*, however, it apparently may be given the count necessary for the line in which it stands; the natural tendency for the post-tonic vowel to drop, particularly between *c* and *l*, makes the 3 syllable count acceptable, as in 33, 35, 47, 81; it seems to have 4 syllables in 46, 51, 78, 190, 199.

§ 5. *Hiatus.* The noun termination *-ion* is counted as two syllables or as one, with about an equal number of cases each way. With hiatus: *significatïonne*, 28; *addicïon*, 54, 68, 223; *subtraccïon*, 55; *duplacïon*, 56; *mediacïon*, 57, 126; *diuisïon*, 59, 254; *condicïon*, 69. Also *quocïens*, 261, 271. Without hiatus: *Addicion*, 62, 82, 117, 124; *subtraccion*, 94; *duplacion*, 120; *diuision*, 216; *quociens*, 255, 262.

Other nouns: *lüe*, 13, 16, 19, 72, 75, 144, 263; *lïeu*, 50; *chïef*, 83. On the other hand, *lue* (1 syll.) 21, 27, 45, 77, 195, 203, 208, 263; *lieu*, 259; *chief*, 180.

Verbs: Here as above the author seems to use perfect liberty in counting personal endings, and even an infinitive with a vowel stem. The cases are approximately evenly divided between hiatus and elision.

3rd. sing. pres. ind.: *survïent*, 44, 194; *vïent*, 78, 204, 206; *couïent*, 220. Without hiatus: *survient*, 123, 203; *vient*, 48, 74; *couient*, 31, 89, 143?, 259. 2nd. plur. ending: *passïetz*, 92, 118; *ouhtïez*, 135; *medyrïetz*, 137; *oghtrïez*, 171; *voilïetz*, 166, 170, 253; *escriuïetz*, 49, 191, 231; *purpensïetz*, 40.

Without hiatus: *passietz*, 174; *voilietz*, 94, 120, 160, 217, 268; *escriuietz*, 96, 104, etc.; *metterietz*, 66; *addietz*, 71; *auiez*, 182, 211, 225; *irrietz*, 123; *gardiez*, 136, 266; *oblietz*, 266; *escriuerietz*, 154; *multiplietz*, 201, 270; *doutiez*, 210; *mettiez*, 219. Infinitives: *medïer*, 129, 142; *multiplïere*, 160, 165?; but without hiatus, *medier*, 107; *multiplier*, 176, 186. Future stem: *signifïera*, 20; but *salliera*, 193. Past participle: *medÿee*, 141, *medïee*, 156. Present participle: *multiplïant*, 163, 174, 180, 185, 198; but *multipliant* (3 syll.), 192, 195, 213?.

Other words: *tïers*, 9, 19, 56; *tïel*, 69, 157; *süant*, 75, *seuant*, 243, *süand*, 233; *luÿ*, 110, 143 (see note); *noëff*, 16, 252; *nïent*, 131; *loür*, 239; *rïen*, 265. Without hiatus: *tiel*, 15; *suant*, 29, 107; *ensuant*, 93, 119; *luy*, 148, 203, 205; *nient*, 141; *rien*, 26, 105.

The following cases are less certain: *faïtez*, 68; *cëaus*, 43 (cf. *ceaux*, 12); *püis*, 51; *füist*, 273; *bïen*, 67; *poïetz* (3 syll.) 229;

aueïgnduroit, 147; *surueïgnant*, 258 (cf. *sureigniantz*, 3 syll., 212).

§ 6. *Elisions.*

1. Elision is less frequent than hiatus. The clear cases are almost all of final neutral *e* before a word beginning with a vowel: *qe un*, 25; *tanque un*, 24, 34; *estre ouel*, 101; *lyne a*, 121; etc. Other cases are *sa office*, 35, 45; *si asquisiste*[*z*], 255; *serrai escript*, 256. There is a total of about 23 clear cases of such elision. More often such juxtapositions were counted as separate syllables: *qe el*, 18; *si en*, 17; *qe un*, 11; *cifre appellerietz*, 11; etc. (cf. § 1, above). Some difficulty in determining the author's use of elision is caused by his frequent discounting of a final neutral *e* before even a consonant (cf. § 1, 1; § 3, above), and by his capricious counting of the abbreviated *figure* and other words (cf. § 4, above).

2. In the following cases the author seems to discount a neutral *e* within the word: *illo(e)ques*, 90; *escriu(e)roi*, 90; *escriu(e)rietz*, 154; *descriu(e)re*, 40 (cf. *escriure*, 161, 253); *leu(e)roi*, 172, 214, 275; *seru(e)roi*, 267; possibly also *joign(e)retz*, 149. On the other hand, *escriueroi*, 4 syll., 76; *deuerois*, 3 syll., 88; *prouera*, 3 syll., 117.

3. In 29, 107, *suant* has 1 syll.; but 2 in 75, 243, 233.

4. In a few cases the author apparently elided a semitonic or intertonic stem vowel with the vowel of the ending: *poetz*, 102, 106?; *devoietz* (2 syll.), 102; *poiet* (rimed with *soit*), 135; *soiet*, *doiet*, 263, 262; *poietz* (1 syll.), 235, 240; *pussoient*, 238; *auoietz*, 264; however, *poent*, 101, and *voietz*, 168, have 2 syll. each.

5. *Ouesk* appears to be 1 syll. in 249, but *ouesque* counts as 3 syll. in 145. Likewise *desouel* may be counted as 2 syll. in 152, but as 3 syll. in 134, 146. Cf. *ouel*, 101, and *oueil*, 131, 132, 2 syll. in each case.

§ 7. *Lines remaining irregular.* About thirty-nine lines remain irregular; of these, obvious emendations correct three 42, 73, 29. See notes. Line 254 is apparently corrupt. Six syllable lines: 100, 137. Seven syllable lines: 38, 46, 95, 190, 217. Seven syllable lines including a hiatus: 20, 59, 129, 185, 233, 273. Seven syllable feminine lines (possibly counted as eight? See above, § 1, 3): 7, 23, 52, 61, 87?, 150, 196, 260, 272. Nine syllable lines: 109, 154, 215, 225, 226. Ten syllable lines:

121, 127, 155?, 167, 176, 181, 187, 262.

Since only the three lines emended, and line 254, are at all incomprehensible, it is to be concluded from this high proportion of irregular lines that the poet accepted approximate equality of length as sufficient. (See above, § 1, 2).

V. — Linguistic Peculiarities

§ 1. *Phonological peculiarities common to Norman and Anglo-Norman dialects.* (I have followed the summary given by Vising (15) in pointing out these traits).

1. *o* or *u* istead of *ou*, *eu*, of central French : *Pur*, 109; *purpensietz*, 40; *curret*, 36; *escotiez*, 86; *dublietz*, 122; *oghtrietz*, 171; *demur*, 205; *dutiez*, 210. 2. *ei* for *oi* : *creiste*, 196; *cheirra*, 192, 197; *sieit*, 230; however, the relative lateness of the text is indicated by the reversion to *oi* in many forms : *devois*, 109, 110, etc.; *pussoient*, 238; *troi* (for *tres*), 175 (16). 3. Confusion of *ain* and *ein* : *attendre*, 170, rimed with *maindre*, 171. 4. *ie* for *e* : *dieuz*, 218, 245, etc.; *tropsovient*, 235; *tiel*, 279, etc. 5. Fall of pretonic *e* : see several examples under versification, (IV, § 6, 2). The decay of declension is also characteristic. (See VI, § 1.)

§ 2. *Peculiarities cited by* Vising (17) *as especially Anglo-Norman.*

1. Phonology : *e* for *ie* : *maner*, 30, 177, etc.; *primer*, 72, 75. 77, etc. In general, however, the contrary tendency is evident (§ 1, 4) ; confusion of *u* and *o* : *chescon*, 12, 53, etc.; confusion of *u* and *ui* : *suant*, 28, 75; *nult*, 158, rimed with *ensuyt*, 159; fall of posttonic *e* in rimes; neutral *e* not counted in interior of verse : numerous examples under Versification, IV, § 2, § 3; confusion of *ñ* and *n* : *veignont*, 114; *veignant*, 126; *aveignduroit*, 147; *meignyere*, 166; *teignerai*, 209; *th* for *t* : *southrere*, 119. 2. Morphology : the forms of the definite article, *lu*, *lui*, cited by Vising, do not occur; an analogous form, however, is the frequent *du* for *de*, 41, 60, etc There are a few cases of the shift to the conjugation in *-er* : *failler*, 167; *escriere*, 164; *descriuere*, 40; and at least one sigmatic preterite : *fuist*, 273.

(15) Vising, *op. cit.*, p. 28.
(16) Ibid., p. 32.
(17) Ibid., pp. 29-31.

3. Syntax. The use of tonic instead of atonic personal pronouns is very common. (See VI, § 9.) 4. A few orthographical traits : *soeul*, 248; *pee*, 280, *pees*, 281, 292; *subtreere*, 228; *poustee*, 157. 5. A few forms of vocabulary are close to Anglo-Norman forms cited by VISING : *chescon*, 12, 53, etc.; *unkore*, 289; *ouesque*, 145, *ouesk*, 249; also *ceo*, 117; *ceaux*, 12; *ceaus*, 43.

VI. — FURTHER LINGUISTIC PECULIARITIES

§ 1. The case distinctions have entirely disappeared, singulars being regularly without *s*, plurals with *s* (or *z* : *totez*, 115; *foitz*, 250, 252, etc. Cf. the rimes, *s* with *z* or *sz*, IV, § 2). There is one plural without *s* : *espece*, 52.

§ 2. Due to the weakness of final neutral *e*, the agreement of adjectives is sporadic. The ordinals do not have a feminine inflection : *la primer*, 8, etc.; *la second*, 9, etc. *Bon garde*, 80; *bone gard*, 162. The author does generally observe the agreement of past participles, when used as adjectives or with the auxiliary *estre* : *la un... outhee... serrai contee*, 150-151; *la disme mediee*, 156; *la figure... serroi rafuie*, 202.

§ 3. The Latinisms *algorismus*, *digitus*, *articulus*, *compositus*, indicate that the scribe was not familiar with other Old French arithmetical texts. (See I, § 3.) There is one case of a Latin accusative : *digitum in digitum*, 167.

§ 4. The articles are usually, masc., *le*, *les*, fem., *la*, *les*; *le* occurs twice with *figure* (243, 200); the feminine singular article contracts sporadically : *del figure*, 107, 198; *au figure*, 29, 108, 128; *al altre figure*, 186; *l'ordre*, 125.

The indefinite article is, masc., *un*; fem., *un*. *Une* occurs twice in the miscellanea, but not in the algorism : *un altre figure*, 159; *un cifre*, 11, 25, etc.

§ 5. The possessive adjectives are those normal to Old French : *son*, *sa*; *lour*; *vostre*.

§ 6. The demonstratives are *cel*, (masc. and fem.), *icel*; plural, *ceaux*, *ceaus*, (masc. and fem.); *queste lesson*, 63.

§ 7. The distributive *chescon* is also invariable : *chescon figure*, 66.

§ 8. The subject pronouns : the first person singular is *ieo*, 183; second person plural, *vous*, 10, 22, etc. The third person

pronouns are usually, masc. *il, ils*; fem., *el, els*; *il* is feminine in 14, 132; *els*, on the other hand, is masculine in 221, 222, 223.

A proclitic *i* for *il* is found in *icouient*, 130, 143, 234; *isoit*, 43; *ytient*, 195; proclitic *i* for *ils* in *isont*, 5, *ysont*, 218. Enclisis of *il* occurs once: *quel couient*, 89; the subject pronoun is omitted once, with *couient*, 31.

§ 9. Object pronouns: we find *luy* crowding out all other third person forms; it is disjunctive, *du luy*, 110, etc.; direct object, 85, 132, 143, 205, etc.; indirect object, 153. Only once do we find *le*, (referring to *la remaint*), in 266; it is direct object.

Soi occurs as the tonic reflexive in 53, *s'* as the atonic reflexive in 46.

§ 10. The verb system is not very completely represented in this text, the majority of the forms being second person plurals. It is difficult to distinguish between futures and conditionals, and present indicatives and subjunctives, because of the uncertainty of the diphthongs *ei*, *ie*, *oi*, of the value of *ñ* and *n*, and of the value of a final neutral *e*, omitted or written. (See IV, § 1.)

The forms *entendes*, 6; *escriueroi*, 76, 90; *devois*, 109, 110, 228; *dirrois*, 8; *deuerois*, 88, are all second person plural. Even in the face of *deuoitz*, 102, 243, I have regularized only to the extent of adding an *s* to *escriueroi*. *Solaistes*, 111, and *voiste*, 155, are second person plural, past definite; I have regularized these to *solaistez* and *voistez*, in view of *comensaistez*, 215; *miestez*, 274; *fiestez*, 275; and *fistez*, 187. However, as pointed out above, the scribe frequently interchanges *s* and *z*. (IV, § 2; VI, § 1.)

The third person singular, future indicative of *estre* offers a peculiarity: it is *serrai* in 81, 82, 95, 98, 151, 207, 217, 256; *serray*, 144; *serroi*, 72, 202, 224, 260, with no clear evidence that it is conditional. *Serra* occurs in 116, 140, 173, 177, and *serront* in 222. *Estre* is the only verb which has this variation, except one occurrence of *teignerai*, 209.

§ 11. The preceding remarks are, in general, confined to the text of the algorism. The miscellanea offer one or two additional points, as the form *feonnt*, 278, 280; the feminie *une*, 284, 293 (18).

(18) Some of the above peculiarities have been pointed out by EMILE BUSCH (*Laut- und Formenlehre der anglonormanischen Sprache des XIV. Jahrhunderts*, Greifswald, 1887) and by HENRY MOISY (*Glossaire comparatif anglo-normand*,

Algorismus

[I. Numeration] 10.9.8.7.6.5.4.3.2.1. [fol. I^{vo} col. a]

Cest art algorism hom apele
Vn art d'aconter bon e bele
En q*uel* disz figures sont app*r*endre
Et de q*uel* sors isont entendre.
Entendes q*ue* de party dextre
Connt cest art vers la sinestre
Un la p*ri*mer figure dirrois
Deuz la second; la tiers trois.
Tanq*ue* a darraine vous venietz
Qe un cifre appellerietz.
Chescon de ceaux, si bien dirretz,
Si en p*ri*mer lue mettez
Il signifiet tansolment
Ffors q*ue* a tiel figure apent.
Si en second lue soit mis
El signifiet tantfoitz disz
Qe el signifiet deuant.
Mes en tiers lue p*ro*chant
Cent el signifiera.
Le quarte lue mile auera.
Et si incontrez vous sans gyle
Par disz, p*ar* cent et p*ar* mile
Tanq*ue* a darraine vous venietz.
Qe vn cifre vo*us* appellerietz,
La cifre rien signifiera
Mes un lue el ocupera.
Mes significationne
Au figure suant la cifre donne.
Trois maners du nombre sont app*r*endre
Les nonnes de q*uel*s couient entendre.
Le p*ri*mer nonne est digitus

Caen, 1889. Introduction); but, compact as it is, the summary by Vising is the most helpful.

Line 29 : *donne :* Ms. *donnez.*

Articulus et compositus.
Digitus dirretz tanque a disz,
Et dunk articulus tient sa office
Et curret par disz ouelment
Par vint, quarrant, mile et cent.
Quelly est compositus :
De digitus et articulus.

[II] Si vous purpensietz descriuere
Un nombre du table ou de liure
Ainsy vous [tenetz] bien a droit [fol. I$^{v\bullet}$ col. b.]
Quel de ceaus nombres isoit.
Si le digitus suruient
En primer lue sa office tient.
Si articulus sus s'adresse
Un cifre primes, articulus apresse.
Si compositus vient auant
Vous escriuietz maintenant
En primer lieu digitus
Et puis apres articulus.

[III] En cest art sont sisz espece
Chescon par soi tient sa office.
La primer est addicion.
La second est subtraccion.
La tiers est duplacion
La quart est mediacion
La quint est multiplicacion.
La sism est diuision.
Add. sub. medi. du partie dextre
Du. di. multi. du sinestre.

[IV. Addition] Si voilietz faire addicion
Prenez garde a queste lesson.
Dieuz lynes scriueretz vraiment
La vn sous laltre ouelment.
Et chescon figure metterietz
Soutz altre, si bien sacetz.

Lines 42-85 incl. are partially obscured by a wrinkle in the Ms. The readings are due to Prof. KARPINSKI.

Line 46 : *s'adresse :* Ms. *sa dresse.*

Line 61 : in the left margin, *no*[*ta*].

Donk faitez addicion
De soutz tiel condicion
Qe si digitus ferietz
De les figures q*uel*s vous addietz
En p*ri*mer lue serroi mis
Digitus cel est la pris.
Si compositus vient au*a*nt
En le p*ri*mer lue suant
Escriueroi[s] vo*us* artic*ulus*
Et en p*ri*mer lue digitus.
Si artic*ulus* vient du less
Un cifre p*ri*mes; artic*ulus* ap*res*.
Mes p*re*nez bon[e] garde tandis
Coment artic*ulus* serrai mis :
Il serrai mis en addicion
En la chief son compaignon
Qu[i] par soi meisme estoire nult
Si nul compaignon luy ensut.
Or escotiez a mon diste : [fol. 2ro col. a.]
Si un cifre soit escrit[e]
P*ar* q*uel* vous deuerois ouerr
Q*uel* couient la cifre ouhter,
Et illoeq*ues* escriueroi[s] vous
La figure du sus ou de soutz.
Puis apres passiez auant
Adder*e* les figures ensuant.
[V. SUBTRACTION] Si voiliez faire subtraccion
Cest serrai vostre lesson.
Escriuietz dieuz lynes maintenant
Sicom la lesson diste deuant.
De sus serrai un nombre graindre
Et de soutz le nombre maindre.
Ou de soutz, ou de sus
I poent estre ouel tot deuz.
Donk si vo*us* poetz vo*us* deuoietz subtrere

Lines 87-89 : in l. marg., a numerical illustration, bound in.
Lines 95-98 : in l. marg., a numer. ill., bound in.

La p*ri*mer fig*ure* de la p*ri*mer
Ceo q*ue* remainte escriuietz bien;
Vn cifre si remainte nul rien.
Si p*ri*mer de p*ri*mer treer ne poetz
Un del figure suant ouhtiez
Quel un au figure deuant mis
Deuois conter et tener p*ur* disz.
Et du luy deuois subtrer*e*
Le nombre com vo*us* solaiste[z] faire,
Et escriuietz la remenant
Sicom la lesson diste deuant.
Si cifres veigniont du vostre faite
Q*uan*t vo*us* hauietz totez subtraite
Chescon cifre noeff serra,
La addicion ceo p*ro*uera.
Puis apres passietz auant
Southrere les figures ensuant.

[VI. DOUBLING]
Si voilietz faire duplacion
Escriuietz vn lyne a vostre lesson,
Puis la primer figure dublietz
Et ceo q*ue* s*ur*uient escriuietz
Selon q*ue* lordre de addicion,
Vous ensenia en sa lesson.

[VII. HALVING]
Si mediacion soit veignant
Escriuietz vn lyne sicom deuant
Puis irrietz au fig*ure* p*ri*mer
Pur icel a medier.
Mes p*re*nez garde kar i couient [fol. 2r° col. b]
Si el soit oueil ou nient.
Sil soit oueil luy medietz,
Et q*ue* remaint donk escriuietz.
Si la figure desouel soit
Ouhtiez vn quel ne poiet
Estre medye, mes bien gardiez
Qe vo*us* medyrietz

Lines 100-102 : in l. marg., a numer ill., bound in.
Line 111 : *solaistez :* Ms. *solaistes.*
Lines 120-121 : in l. marg., numer. ill., bound in.
Line 125 : *ensenia :* Ms. *ensenietz.*

La vn quel vous hauiez ouhtey.
Ffaitez vn estrik de surluy
Quel serra signe du verité
Qe la est un nient medyée.
Si la vient un a medier
I couient luy tot outher;
En son lue serray escrit
Vn cifre ouesq*ue* vn strik.
Si la second desoueil soit
Sicom il aueignduroit
Vn de luy vous outhoirietz
En cinc ad figure deuant joignerietz
Kar la vn deuant outhée
Ad luy p*ur* disz serrai conntée.
Sil second soit desouel v*ir*tue
Vn cifre luy konstera de son lue
Et cinc escriuerietz maintenant
Ad la figure q*ue* voiste[z] deuant
Pur la disine mediée,
Kar el est du tiel poustée.
Vn cifre estoire ia*m*mes ne nult
Mesk quant vn altre figure ensuyt.

[VIII. MULTIPLICATION]
Si vo*u*s voilietz multipliere
Dieuz lynes vous deuietz escriur*e*
Mes prenez bone gard a tant
Ke del nombre multipliant
La primer figure deuietz escrier*e*
Soutz darraine a multipliere.
Si vous voilietz bien meignyere
Digitu*m* in digitu*m* sans failier.
P*ar* q*ua*nt le grayndre nombre voietz
De deinz diz est bien regardietz;
Si la vous voilietz attendre
Tantfoitz oghtrie[z] vo*u*s le maindre
De son disme et puis leuera
Le nombre verrai q*ue* serra.

Line 141 : in rt. marg., a figure 1.
Lines 144-145 : in rt. marg., zero with a line above it.
Lines 163-165 : in rt. marg., numer. ill. $\begin{smallmatrix} 3 & 5 & 9 \\ 4 & 2 \end{smallmatrix}$

Passietz or en multipliant
Qe est troi dure a luy prouant.
La darraine del nombre a m*u*ltiplier [fol. 2ᵛᵒ col. a]
Serra m*u*ltiplie en tiel maner :
P*ar* touz les figures q*ue*ls sont enbas,
Si dist la lesson du cel cas.
Et del chief del m*u*ltipliant
Escriuietz le nombre q*ue*l port auant.
Et q*ua*nt vo*u*s auiez multiplie
Meisme la figure sicom ieo dye
Excriuietz les figures auant
Del nombre m*u*ltipliant
Al altre figure a multiplier,
Et faitez sicom vous fistez son frer.
Mes prenez garde en cest reson,
Totdiz en m*u*ltiplicacion
Si artic*ulu*s sus leuetz
Sicom ieo dye escriuietz :
Del m*u*ltipliant la cifre cheirra
Le nombre outre salliera.
Mes zi digitus suruient
Del m*u*ltipliant son lue ytient.
Si compositus sus creiste
Digitus cheirra s*ur* la teste
Del figure multipliant
Artic*ulu*s outre salliant.
Q*ua*nt [par] le fig*ure* qest soutz mis
M*u*ltiplietz laltre q*e*st sus siess
La figure de sus serroi rafuie
Ceo q*ue* suruient en lue du luy.
Si vn cifre vient de sure
Vous luy passerietz sans demur*e*.
Si vn cifre vient en bass
La figure amonte serrai durass
Et en meisme le lue de luy

Lines 191-193 : in l. marg., $\overset{102}{58}$.
Lines 195-197 : in l. marg., $\overset{122}{69}$.
Lines 202-204 : in l. marg., $\overset{302}{14}$.
Lines 206-208 : in l. marg., $\overset{34}{20}$.

La cifre teignerai sa partie.
Si vous en dutiez de la cas
Qe vous auietz bien faite ou pas
Diudez le nombrez *sur*ueigniantz
P*ar* les figures multipliantz
Et meisme le nombre leu*er*oi arer
Au quel vous comensaistez primer
[IX. Division] Si voilietz faire diuision
Cest serrai vostre lesson. [fol. 2v° col. b]
Escriuietz dieuz nombr*es* q*uel*s q*ue* ysont
Et mettietz le graindre nombre amont.
Ceo couient il bien recordre :
Coment els serroint mis en ordre.
Els serront mis en cest lesson
Come els sont en addicion.
Darraine soutz darraine serroi mis
Sicom deuant vous auietz apris.
Puis comencez a partie sinestre
De diuidier, si uult il estre.
La figure de soutz deuois s*ub*treere
Tantfoitz com vo*us* poietz faire
De icel figure q*ue* sieit de sus.
Mes escriuietz la surplus
La ou q*ue* lordre v*ous* comand
En la lesson en suand.
Mes prenez garde, kar icouient,
Vous poietz subtreer luy t*ro*psouient;
Pur ceo gettiez deuant vos ieus
Qe touz laltres figures de ius
Pussoient tantfoitz estre subtrest
Del figures sur lo*ur* teste.
Mes si vous ne poietz diuider
La primer figure del primer

Lines 206 209 : cf. WATERS : A fifteenth Century French Algorism, p. 222, 298-99 : Se cyfre est desos, si le mes
: Deseur lis ses lieu vuis est.
Line 227 : *uult* : Ms. *mult ?*
Lines 239-41 : in rt. marg., numer. ill., illegible.
Line 240 : in l. marg., a mark similar to contraction used in *no*[*ta*].

Mettez le nombre de soutz auant
Ad le primer figure seuant.
La primer figure deuoietz donc
Subtreer de laltres dieus amont
Issink q*ue* vo*us* tantfoitz s*u*btreez
Les altres figures q*ue* sont apres.
Si vn soeul figure auient
Onerer ouesk luy, il couient.
Sie plus*our*s foitz vous poirietz
Subtreer vn figure si bien sacez
Ky noef foitz, si dist le liure,
Si la vous voilietz escriure
De diuision du gentz.
Si asquiste[z] vn nombre quociens
El serrai esc*ri*pt en chescon houre
Amont la primer diuisoure.
Si vn sault soit s*ur*ueignant
Mettez vn cifre en lieu vacant,
Quel serroi sa residence [fol. 3ro col. a]
Venant le nombre quociens,
Ky le quociens p*er*isschier ne doiet;
Sanz ky le lue vacant soiet.
Q*ua*nt vous auoiez diuisie bien
Si la remaint asonn rien
Le gardietz bien, ne oblietz pas,
Il serueroi vous en altre cas.
Si vous voiliez prouer cest cye,
Ke vous haietz bien departye,
Le diuisoure multiplietz
Per q*uo*ciens, et suraddietz
Ad le nombre multiplie
Cest quel fuist deuant gardie
Et le nombre quel primer miestez
Sus leueroi si bien le fiestez.

Lines 247-249 : in rt. marg., numer. ill., illegible.
Line 248 : in l. marg., a mark similar to contraction used in *no*[*ta*].
Lines 252-254 : in rt. marg., numer. ill., illegible.
Line 254 : in l. marg., *no*[*ta*].
Line 258 : in l. marg., a mark similar to contraction used in *no*[*ta*].

Explicit ars subtilis computandi que dicitur
[Algorismus.

The Miscellanea

§ 3 graynes d'orge en mye l'espye
Ffeonnt vne ruche la voirs vo*us* dye.
10 ruche de tiel factoure
Ffeonnt vn pee de leal mesure.
5 pees vn pas feonnt
125 pas vn lue sont
Vn lue d'engle*terre* dublée
Vne lencke en france e*st* appellé
Ky cest art volt bien garder
Il poet connter leggerment
Q*ua*nt g*ra*ynes dorge poent ioesere
Ent 20 Lues ou en 100.

§ Escotiez vnkore leal fitz a moy
La mesure de terre vo*us* plus dirroi
Vn perche contient de leal mesure
18 pees sanz plusours [fol 3ro col. b]
Vne acre de terre contient atant
De fyne a fyne p*er*chez 40
Et detrauers si bien le serchietz
Contient lacre fors 4 perchez.
Si poet il bien estre prouee
Q*ua*ntz de leures poent seer
A mettre chescun en vn pee
Par mye vn tiel acre de terre.

§ Dieux soit ou vous q*ua*nt vous alietz
Et de vos malx vo*us* doynge p*ar*donne
Pensez de moy q*ua*nt meux porretz
Qe 78 hauetz a nonne.

Line 283 : *d'engleterre :* Ms. *dengletr ;* cf. *terre*, abbr. tre, 298, 305.
Lines 301-304 : in rt. marg., a crown over the numeral 78.

§ 305 Ffyue fete maken a pase
A hundreth twenty and fyue
Pase a forlong mase (make).
Aght forlong maken a myle
Two myle a lencke *with*outen gyle.

§ 310 Adder, southrer et medier
A partye destre doit comencer.
Duplier, m*u*ltiplier et diuider
A sinestre tynent lour inister.
Une fig*ur*e mis en le p*ri*mer lieu signifie
315 T*a*nt soulement soi meismes; el second
Lieu signifie disz foitz soi; el tiercz lieu
Centfoitz soi; en le q*ua*rt lieu milfoitz
Soi; el q*ui*nt lieu disfoitz milfoitz;
El sisme lieu centfoitz milfoitz
320 Soi. el septisme lieu milfoitz
Milfoitz soi; en le octisme lieu
Disfoitz milfoitz milfoitz soi; en le
Noefisme lieu, centfoitz milfoitz
Milfoitz soi : el disme lieu, mil
325 Foitz milfoitz milfoitz soi. Et
Ensi aconnterez come auant par
Disz, cent et mil et outre come
V*o*tre sen vous pura seruir.

VOCABULARY

[An asterisk indicates that the word or the meaning adopted is not found in the dictionaries of TOBLER-LOMMARTZSCH (down to *cl-*) or GODEFROY (from *co-*), nor in the *Glossaire comparatif anglo-normand* of HENRI MOISY (Caen, 1889). All technical words are included.]

Aconter, *v.* 3; aconnterez, 326, *count, reckon.*

acre, *sf.* 293, 296, 160 *sq. perches.* (In addition to above mentioned dictionaries, see MOISY, H. : *Glossaire du patois normand;* the dictionary of LA CURNE DE SAINT-PELAYE; the incomplete *Dictionnaire historique de l'Académie Française.*)

* addere, *v. a.* 93 *etc.*
addicion, *sf.* 54, 62 *etc.*
adresse, *3rd s. pres. ind. of* adrecier, *v. refl.*, 46.
apent, *3rd. s. pres. ind. of* apendre, *v.* 15, *to be attached to.*
apresse = apres, *adv.* 47.
* articulus, *sm.* 33, 35 *etc. a number divisible by ten.*
asonn, *3rd s. pres. ind. of* assomer, *v. a., to total.*
asquiste[z], *2nd pl. past def. of* aquerre, *v. a., to get, acquire.*
attendre, *v.* 170, *accomplish, execute.*
auant = *see* venir auant; port auant; passer auant.
aueignduroit, *3rd s. cond. of* aveindre, *v.* ? 147, *happen.*
* auera, *3rd s. fut. ind. of* aveir, *v. a.*, 21, *to be worth.*
cest cye = ceci, 268.
cheirra, *3rd s. fut. ind. of* cheir (*Central French*, cheoir), 192.
chief, *sf.*: en la chief, 83, *ahead of;* del chief, 180, *ahead of, above?*
cifre, *sf.* 11, 25, 26 *etc. zero.*
* compositus, *sm.*, 33, 38 *etc. a figure above ten not divisible by ten.*
creiste, *3rd. s. pers. ind. of* creistre, *v.*: sus creiste, 196, *results.*
* deinz, *prep.* 169 *within.*
departir, *v. a.* 269, *to divide.*
descriuere, *v. a.* 40, *to write.*
* desouel, *adj.* 134, 146 *odd (of numbers).*
* detrauers, *adv.* 295, *across.*
* digitus, *sm.* 32, 34 *etc. digit, number below ten.*
* disine, *sf.* 156, *ten;* 172, *ten-times.* (See this word in vocabulary of E. G. R. Waters, *A Thirteenth Century Algorism in French Verse*, in *Isis*, XI (1928), pp. 45-84.)
* diuider, *v. a.* 240, diuidier, 227.
diuisie, *past part. of* diuider, 264.
diuision, *sf.* 59, 216 *etc.*
* diuisoure, *s.* 257, 270, *divisor.*
dublietz, *pl. imperative of* dubleir, *v. a.*, 122.
* duplacion, *sf.* 56, 120, *doubling.*
* durass, *past part. of* desrayer, *v. a.*? 207, *to erase, eradicate?*
ensuant, *adj.* 93.
entendre, *v. a.* 5, *to understand.*
escriuere ad, 154-155, 184-186, *to add to.*
* espece, *sf. pl.* 52, *fundamental operations.*
* espye, *sf.* 277, *spike of grain.*
estoire, *a corrupt form of* estoveir? 84, 158, *must be, is always.*
* estrik, *sm.* 139 strik, 145, *a line above a figure to indicate the halving process.*

figure, *sf.* 4, 8, 15 *etc.*
fitz = fi? (*Cf.* GODEFROY): leal fitz, 289, *with loyal confidence?*
garder, *v.* 136, *take care; v. a.* 266, *keep.*
* gentz, 254, ?
* incontrer, *v.* 22 *to move backward (i. e., to the left).* [*Derived from* incontra?].
* inister, *s.* 313, *beginning.* (*Cf.* inicion, GODEFROY).
* ioesere, *v.* 283 = *gezir?*
* issink = ainsi, *adv.* 246.
joignerietz ad, 149, *add to.*
konstera, *3rd s. fut. ind. of* conster, *v. a.* 153, *to stand for.*
* lencke, *sf.* 284, *two miles? Cf.* 309.
* leuera, *3rd s. fut. ind. of* leuer, *v. a., to result;* sus leuetz, 190, *you get (as a result).*
* leure, *s.* 298, ?
lue, *sm.* 16, 19, 21, *etc.* lieu, 50, 314 *etc., numerical place.*
* lue, *sf.?* 282, *a linear measure corresponding to the furlong;* lue d'englterre, 283, *the English mile?*
* maignyere, *v. a.* 166, *multiply.* (*Cf.* mener, *in vocabulary of* WATERS, *A Thirteenth Century Algorism*, in *Isis*, Vol. XI, p. 83, *and* meneir, *in voc. of* WATERS, *A Fifteenth Century French Algorism*, in *Isis*, Vol. XII, p. 235.)
mediacion, *sf.* 57, 126, *halving.*
medier, *v. a.* 129, 142.
mettez... ad, 242-243, *put under.*
multipliant, *sm.* 180, *multiplier; adj.* 163.
multiplicacion, *sf.* 58, 189.
multiplier, *v. a.* 176, 186, multipliere, 160, 165.
nient, *adv.* 131, 141, *not.*
office, *sf.* 35, 53 *etc., function.*
* onerer, *v. a.* 249, *to honor?*
ouel, *adj.* 101, *equal;* oueil, 131, 132, *even (of numbers).*
ouelment, *adv.* 36, *likewise, equally;* 65, *equally.*
* ouerr, *v.* 88, *to go astray?*
* ouesk, *adv.* 249, *however;* ouesque, 145, *as well as?*
* passer auant, 92, 118, *continue;* passietz... en multipliant, 174, *continue multiplying.*
pee, *s.* 280 *etc., a foot (linear).*
perche, *s.* 291, 294, 296, *eighteen feet.*
perisschier, *v.* 262, *to go out, hence, disappear.*
* plusours, *adj.* 292, *more.*
port auant, 181, *it results.*

poustee, *sf.* 157, *value, power.*
* prochant, *pres. part. of* approcher, *v. a.?* 19, *to move ahead (i. e. to the left).*
* quelly, *demonstr. pro.*, 38.
* quociens, *adj.* 255, 261, *s.* 271, *quotient.*
recordre, *v. a.* 220.
remaint, *3rd s. pres. ind. of* remaindre, *v.* 104, 105.
* remaint, *sf.* 265, *remainder.*
remenant, *gerund of* remaindre, 112, *remainder.*
rien, *s. indef.* 26, *nothing;* 265, *something.*
* ruche, *sf.* 278, 279, *about an inch.*
* sault, *sm.* 258, *skipping one place when there is a zero in the multiplier.*
sen, *sm.*, 328, *sense need?*
sieit, *3rd s. pres. ind. of* seier, 230.
siess, *past. part. of* seier, *v. a.*, 201, *set, place.*
sors, *sf.* 5, *way, manner.*
strik, *see* estrik.
suant, *adj.* 28, 75.
subtraccion, *sf.* 55, 94, *etc.*
subtrere, *v. a.* 102 southrere, 119 subtreer, 235, 245, 251 subtreere, 228.
* table, *sf.* 41, *a mathematical table? (Cf. two acceptations in* GODEFROY *a writing tablet; a* bureau de changeur.)
* treer, *v. a.* 106, *subtract.*
veignant, *pres. part. of* venir, 126.
virtue, *sf.* 152, *value.*

ENGLISH TRANSLATION

[I] 10.9.8.7.6.5.4.3.2.1. This art is called algorism, a fair and goodly art of counting, in which ten figures are to be learned, and in what way they are to be understood. Understand that from the right hand this art counts toward the left. You will call the first figure one, the second two, the third three, until you come to the last, which you will call a zero. Each of these, if you say it right, means only that much if you put it in the first place, unless a figure follows the mentioned one. If it be put in the second place it means as many times ten as it meant before. But moving up to the third place it will mean a hundred [times]. The fourth place will be worth a thousand [times]. And so you move [to the left] without hesitation by

ten, by a hundred, by a thousand, until you come to the last, which you will call a zero. The zero will mean nothing, but it will occupy a place. But the zero gives meaning to the following figure.

Three kinds of numbers are to be learned, the names of which it is well to understand. The first name is digit, [then] article and composite. You will say "digit" as far as ten, and then the article comes into play and runs through twenty, forty, a thousand and a hundred. The following is a composite: [a number composed] of a digit and an article.

[II] If you propose to write a number from a table or a book, you [begin] thus carefully at the right, whatever of these numbers it may be. If the digit turns up its position is in the first place; if an article appears, a zero first, then the article; if it is a composite, you now write the digit in the first place and then afterwards the article.

[III] In this art there are six fundamental operations; each one has its own function. The first is addition. The second is subtraction. The third is doubling. The fourth is halving. The fifth is multiplication. The sixth is division. Add, subtract and halve from the right hand, double, divide and multiply from the left.

[IV] If you want to do addition, pay attention to this lesson. Draw straight lines one directly under the other, and each figure you will place under the [corresponding one], if you know well how to do it. Then do the addition underneath in such a way that if you get a digit from the figures which you add, the digit which is gotten there will be put in the first place. If it comes out a composite you will write the article in the first following place, and the digit in the first place. If an article results from the problem, a zero first, then the article. But take good care meanwhile how the article will be placed: it will be placed in addition ahead of its companion, which by itself is worth nothing if no companion follows it. Now listen to what I say: if there is a zero written, by which you might go astray, it is necessary to take away the zero, and in place of it you will write the figure above or below. Then afterwards go ahead and add the following figures.

[V] If you wish to do subtraction, this will be your lesson.

Write two lines now, just as the lesson said before. Above will be a larger number and below the smaller number. Whether above or below, the two might be equal. Then if you can you should subtract the first figure from the first; write carefully the remainder; a zero, if nothing remains. If you cannot subtract the first from the first take one from the following figure, which one you should count and remember as ten added to the first figure; and from it you should subtract the number as you usually do, and write the remainder just as the lesson said before. If zeros result from your operation when you have finished subtracting, each zero will be a nine; addition will prove this. Then afterward continue to subtract the following figures.

[VI] If you wish to do doubling draw a line for your problem, then double the first figure and write the result just as the order of addition taught you in its lesson.

[VII] If it is a matter of halving draw a line just as before, then you will go to the first figure to halve it. But have a care for it is of importance whether it be even or not. If it be even halve it, and then write the remainder. If the figure be odd take away one which cannot be halved, but keep in mind that you will halve the one which you have taken away. Make a line over it which will be a true sign that there is an unhalved one. If a one turns up to halve, it is necessary to take it away entirely; in its place will be written a zero as well as (?) a line. If the second is odd, as it might happen, you will take one away from it and you will add five to the preceding figure, for the one taken away before will be counted as ten with the latter. If the second is of odd value, a zero will stand for it in its place, and you will now add five to the figure you saw before for the halved ten, for it is of such value. A zero is never of any value except when another figure follows it.

[VIII] If you wish to multiply you should write two lines, but take good care meanwhile, for you should write the first figure of the multiplying number under the last to be multiplied. You want to multiply digit by digit without error. It is well that you regard by how much (you see) the larger number is from (within) ten; if you want to accomplish it, take the smaller number that many times from its ten-times, and then will result the correct number, which it will be. Continue multiplying now,

for it is very hard to prove (?) The last [figure] of the number to be multiplied will be multiplied in the following way: by all the figures which are below, so says the lesson about this matter. And above the multiplier write the number which results. And when you have thus multiplied the figure as I say, write the figures of the multiplier ahead under the next figure to be multiplied, and do as you did to its brother. But have a care in this matter, always in multiplication, if you get an article, write it as I say: the zero will fall [over] the multiplier, the number will project [to the left]. But if a digit results its place is [above] the multiplier. If a composite results, the digit will fall above the multiplying figure, the article will project [to the left]. When you multiply the figure that is set above [by] the figure which is placed below, the upper figure will have disappeared, the result in its place. If there is a zero above, you will pass by it without delay. If a zero comes below, the figure above will be erased (?) and likewise the zero will have its position in place of it (?). If you doubt of the matter, whether you have done well or not, divide the resultant number by the multiplying figures, and thus you should get back the number with which you first began.

[IX] If you wish to do division, this will be your lesson. Write two numbers, whatever they may be, and put the larger number above. It is well to remember this: how they will be put in order. In this lesson they will be placed as they were in addition. The last will be placed under the last just as you have learned before. Then begin to divide at the left, so it is to be. The lower figure you should subtract as many times as you can from the figure which is set above. But write the surplus where the order tells you to in the following lesson. But take care, for it is well, you might subtract it too often; therefore make sure that all the other figures below can be subtracted as many times from the figures above them. But if you cannot divide the first figure by the first move the number below ahead under the first following figure. Then you should subtract the first figure from the other two above, so long as you subtract as often the other figures which follow. If a single figure comes along, it is necessary to honor (?) it just the same (?) If you know your business, you can subtract a figure as many

times as nine, so says the book, if you want to write there division by... (?). If you get a quotient it will always be written above the first divisor. If a jump happens to turn up, put a zero in the vacant place, where it will stay while the quotient number is forming (?), for the quotient ought not to go out [of place]; otherwise the place would be vacant. When you have divided well, if the remainder amounts to something, keep it carefully, don't forget, it will serve you in another case. If you wish to prove this, that you divided well, multiply the divisor by the quotient, and add on to the multiplied number that which was kept before, and the number you first put down will result if you did it right.

Miscellanea

(1) (l. 277).

Three grains of barley on the spike make one ruche, I tell you the truth. Ten ruches of this kind make one foot of correct measure; five feet make a pace, 125 paces are a lue; a link is called a double English lue in France. He who wishes to regard closely this art can easily count how many grains of barley can lie in twenty lues or a hundred.

(2) (l. 289).

Listen to me again with loyal confidence, I will tell you further the measure of land : a perch contains in correct measure eighteen feet, no more. An acre of land contains from end to end as much as forty perches; and across, if you figure it out right, the acre contains only four perches. So it can easily be proved how many... (?) can be put each in a foot (a foot apart?) in such an acre of land.

(3) (l. 301).

God be with you when you go, and may he grant you forgiveness for your sins. Think of me when best you can, you who are named 78.

(4) (5) (l. 310).

Adding, subtracting and halving should start from the right, doubling, multiplying and dividing have their beginning at the left. A figure put in the first place means only as much as itself; in the second place it means ten times itself; in the third

place a hundred times itself; in the fourth place a thousand times itself; in the fifth place ten times a thousand times itself; in the sixth place a hundred times a thousand times itself; in the seventh place a thousand times a thousand times itself; in the eighth place ten times a thousand times a thousand times itself; in the ninth place, a hundred times a thousand times a thousand times itself; in the tenth place, a thousand times a thousand times a thousand times itself. And thus you count as before by ten, a hundred, a thousand and so on as the [appropriate] meaning may serve you.

(Paris) CHARLES N. STAUBACH.

The first explanation of decimal fractions and measures (1585). Together with a history of the decimal idea and a facsimile (no. XVII) of Stevin's Disme

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N. B.—This paper is a continuation of my paper on SIMON STEVIN of Bruges (1548-1620) published in *Isis* 21, 241-303, 1934. The first paper was divided into 63 sections, and the sections of the present paper are numbered from 64 to 121; this was done for the sake of the index common to both.

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67. Other editions of the *Arithmétique* and of the Flemish *Thiende*.
68. English *Disme*, translated by ROBERT NORTON, 1608.
69. RICHARD WITT, 1613; HENRY LYTE, 1619; WILLIAM BARTON, 1634.
70. Analysis of STEVIN'S *Disme*.

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90. Division by $a.10^n$. REGIOMONTANUS (1463), PIETRO BORGHI (1484), FRANCESCO PELLIZZATI (1492), CHRISTOPH RUDOLFF (1525).

91. False decimal dots.

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97. From 1601 to 1625. J. H. BEYER (1603). R. NORTON (1608). B. PITISCUS (1608, 1612). KEPLER (1616). J. BÜRGI (1620). NAPIER (1617, 1619). E. GUNTER (1620). H. BRIGGS (1624).

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I. — De Thiende, 1585

64. The fourth work published by Stevin and one of his main titles to fame is a little pamphlet of 36 p. in Flemish entitled *De Thiende*, meaning the tithe, which was printed by Christoffel Plantijn in Leiden 1585 (fig. 31). This pamphlet is exceedingly rare but a facsimile reprint of it together with an introductory study of 41 p. was published by Father H. Bosmans in Antwerp 1924 (*Isis* 7, 543).

Stevin himself prepared a French translation of *De Thiende*, entitled *La Disme*, which was printed in the same shop and appeared in the same year, being a part of the *Arithmétique*, or more exactly of the *Pratique d'arithmétique*, which forms the second volume of the *Arithmétique* but has an independent title page and might pass as an independent publication (1). (See figs. 51-53.)

As the Flemish and French texts were both written by the author, edited by him, and published at almost the same time in the same printing shop, they have practically the same standing as original sources of Stevin's thought.

65. The printer Christoffel Plantijn was granted by Maurice, count of Nassau, in the name of the States General the exclusive right of publication of *De Thiende* in Dutch, French and Latin in the Netherlandish Provinces for six years. This privilege is dated Delft, December 20, 1584. To show how close the Flemish and French publications were in point of time, it will suffice to point out that the privilege of the *Arithmétique* bears the same date (2). In fact the priority of the Dutch text is established only by Stevin's own statement at the beginning of the *Disme* (see our facsimile) " Premierement descripte en

(1) Except that the *Pratique d'arithmétique* and its contents are already mentioned on the title page of the *Arithmétique* (see our facsimiles). This is typical of many Stevinian editions, which were so arranged that the parts might eventually be sold as complete units.

(2) The Dutch privilege may be seen in Bosmans' facsimile, p. 37. I have not seen the original edition of the *Arithmétique*, but the date of its privilege is given in the *Bibliotheca belgica* (vol. 23, S. 129, p. 5). According to the same source the *Arithmétique* bears also a privilege granted by the king of France, dated Fontainebleau, August 5, 1582.

Flameng & maintenant convertie en François, par SIMON STEVIN de Bruges." (3)

66. It is interesting to note that in this case STEVIN's mother tongue is correctly called Flameng (i.e., Flemish). On other occasions it was called Belgian, Bas-Allemand, Netherlandish, a matter which I have discussed in my first STEVIN paper. (§ 18, also § 102.)

Considering that STEVIN thought in Flemish and wrote naturally in that language, the Flemish text of the *Thiende* is a little more authoritative than the French. For example, if there were any divergence between the two texts, the Flemish text should be accepted as the more truly Stevinian. However, I am not aware of any divergence in this particular text, except with regard to trifles.

Hence I feel entirely justified in publishing here a facsimile of the French text of this work, the scientific importance of which, as I shall show presently, can hardly be overestimated. Father BOSMANS' facsimile was undoubtedly welcome, but of relatively little use to the scholars unable to read Dutch, that is, to all scholars, except a small minority. The French text which we are now offering to our readers will thus be in a sense the first revelation to the Republic of Letters of that great Stevinian classic in its original garb.

Bibliographical descriptions of *De Thiende* and *La Disme* are unnecessary, in spite of the rarity of these booklets, inasmuch as BOSMANS' facsimile of the former is easily available, and the facsimile of the latter accompanies the present paper.

67. STEVIN's *Arithmétique* of 1585 (including the *Disme*) was twice reprinted after his death by the ELZEVIERS of Leiden, both reprints being due to his famous disciple ALBERT GIRARD (1595-1632): the first time independently in 1625; the second time in the *Œuvres mathématiques* which appeared after GIRARD's own death, in 1634 (see § 12 and 27 of my first STEVIN paper).

Father BOSMANS says that the Dutch *Thiende* was reprinted

(3) On the other hand the Dutch *Thiende* contains at least one reference to the French *Arithmétique*, namely, on p. 18 (door het vierde Probleme onser Franscher Arith.). Hence both texts, Flemish and French, were probably written before either was printed.

in the Dutch translation of NAPIER's *Rabdologia* by ADRIAAN VLACQ (Gouda 1626) (4).

68. The *Thiende* was translated into English by ROBERT NORTON (d. 1635), engineer and gunner, son of the poet THOMAS NORTON (1532-84). This ROBERT NORTON was the author of various works on mathematics and gunnery, and probably also of the verses printed at the beginning of Captain JOHN SMITH's *Generall historie of Virginia*, 1626 (DNB, 41, 219). The English translation is entitled.

Disme: The art of tenths, or decimall arithmetike (London, 1608) (5). (fig. 32.)

There are copies of it in the British Museum, the Cambridge University Library, and the W. A. WHITE library.

69. I have not had an opportunity of seeing it but I examined in the Huntington Library of San Marino two little books devoted to the selfsame subject and which continued the Stevinian decimal tradition in England for a few decades. There is more reason for mentioning these books here because in spite of their importance, they are practically unknown. They are not mentioned in CANTOR's *Vorlesungen*, or in L. C. KARPINSKI's *History of arithmetic* (1925), or in F. CAJORI's *History of mathematical notations* (vol. 1, 1928); nor are the authors dealt with in the *Dictionary of national biography*.

D. E. SMITH just mentions one of them (LYTE) in his *History of mathematics* (vol. 1, 247, 1925), and adds a reference to RICHARD WITT's *Arithmeticall questions* (London, 1613) wherein the decimal fractions are referred to (fig. 38). I have not seen WITT's *Questions*, and only know that they were reprinted together with " sundry sorts of breviats by T. FISHER," in 1634.

The two little books of the Huntington Library are (A) HENRY

(4) BOSMANS : *La Thiende* (1920, 10). VLACQ's book was seen neither by him nor by me.

(5) The form "disme" seems to be a creation of NORTON, which hardly survived him. The common form of that word, dime (or dyme), can be traced back to the fourteenth century, and it is very popular to this day in the United States to designate a silver coin worth one tenth of a dollar.

The French word dîme (anc. disme) has kept the original meaning represented by the English word tithe. Its learned doublet " décime " is used to designate one tenth of a franc, but it has remained a technical and pedantic word as opposed to the popular American dime.

LYTE: *The art of tens, or decimall arithmeticke* (London, 1619) Title, 2 l., 46 p. (fig. 39).

HENRY LYTE, Gentleman, was obviously little known, for he himself invites those of his readers wishing for more information " to repaire to Mr. GRIFFIN [i.e., EDWARD GRIFFIN his publisher]... and there they shall heare where I am, who will be willing to explaine anything that is contayned within this Booke." This was probably a discreet advertisement for lessons, for the authors of arithmetics were often schoolmasters or private teachers. LYTE's book contains an explanation of the four rules of arithmetic together with a table to help the working of division, " secondly it sheweth the rare use of the Art of tens, or decimall arithmeticke devised first by the excellent Mathemitian (sic) Mr. SIMON STEUEN." The author further explains the great advantage of the decimal calculation for " landlord and tenant, merchant, trades-men, surveyor and landmeasurer, money masters and corne masters, grasier and farmer," and naturally finds great difficulty in reconciling these views with the English weights and measures. We shall come back to LYTE presently (§ 104).

(B) [WILLIAM BARTON]: *Arithmeticke abreviated. Teaching the art of tennes or decimals to worke all questions in fractions as whole numbers without reduction...* (London, 1634). (See (fig. 41.)

WILLIAM BARTON is as little known as LYTE. Perhaps he was another teacher, unless he be identical with the hymnologist (b. 1598?-1678?)? The latter is the subject of an article in D.N.B. (3, 348), but no reference is made to arithmetical matters of any kind. BARTON's name does not appear on the title page of the *Arithmeticke*, but only at the end of the Epistle dedicatory to Sir THOMAS RICHARDSON (1569-1635), Lord Chief Justice, and of the preface to the reader. STEVIN is not mentioned in the preface nor anywhere else as far as I could see; but the method of division is said to be that of Mr. BRIGGS. The author explains the use of the NAPIER's bones (see facsimile of title page).

Considering the low repute of such books it is not surprising that they fell into oblivion; nor would I be surprized if other books of the same kind were shown to exist.

70. To return to STEVIN's *Disme*, the complete facsimile of it to be found at the end of this paper is so short that it will not

take the reader long to examine it. Yet it is worth while to analyze it briefly, to indicate the general spirit informing it and to translate a few technical terms.

The dedication " To astrologers, land-measurers, measurers of tapestry and wine-casks, and stereometricians in general, mint-masters and merchants all, SIMON STEVIN, greetings " has such a queer ring that I wonder whether the author did not make it with his tongue in his cheek. Flemings have a peculiar kind of humour, of which I think I have found various traces in STEVIN's works, but as I only saw his words in cold print and did not hear him say them nor see the twinkle of his eyes, I cannot be quite sure.

The preface is psychologically interesting because it shows the strange state of mind induced in the author by the realization on the one hand of the importance of his invention; on the other hand, of its utter simplicity : the matter is so simple indeed that it hardly deserves to be called an invention (facs., p. 133) and yet it *is* an invention and a great one ! How often would such a dilemma perplex the inventor if the instinctive resistance of the world to his ideas did not afford a comforting proof of their novelty and of his genius ! A similar mode of thought was beautifully expressed by the motto which STEVIN attached in the following year (1586) to his statical books (see figs. 6, 7, 8.) in my first STEVIN paper) : " *Wonder en is gheen wonder* "—the miracle is not a miracle after all. MACH explains this so well that I cannot do better than to quote his words :

" ... Every enlightening progress made in science is accompanied with a certain feeling of disillusionment. We discover that that which appeared wonderful to us is no more wonderful than other things which we know instinctively and regard as self-evident; nay, that the contrary would be much more wonderful; that everywhere the same fact expresses itself. Our puzzle turns out then to be a puzzle no more; it vanishes into nothingness, and takes its place among the shadows of history." (6)

This special kind of disillusionment happened to STEVIN at least twice, and this is to me the best proof of his genius.

In the course of his preface, STEVIN explains the merits of his invention, insisting on their very practical nature. The book

(6) ERNST MACH : *The science of mechanics* (3rd ed., Chicago, 1907, 31).

itself is divided into two main parts dealing respectively with the four definitions and the four operations (facs., p. 138).

Definition I. The " disme " is a kind of arithmetic by means of which all accounts and measurements can be completed without fractions—that is, with integers only.

(Rompuz = fractions; disiesme progression = geometrical progression of which the ratio is 1/10.)

Definition II. " Tout nombre proposé se dict *commencement* son signe est tel (0)." (7)

STEVIN's term " commencement " refers to the integer proper which marks the beginning of the decimal progression. The zero is somewhat equivalent to our exponent zero $(\frac{1}{10})^0$ the ratio of the progression being implicit.

Definition III. Defining the successive decimal places, the tenths being called *prime* and designated by the symbol (1), the hundredths being called *seconde* and designated by (2), etc.

Definition IV. The numbers thus defined (Def. II and III) are called *nombres de disme*, i.e., decimal numbers.

These four definitions introduce the different names and symbols of decimal numbers.

Thus the number which we write today 8.937 was written by STEVIN 8(0)9(1)3(2)7(3) and read by him (in French) 8 commencement 9 primes 3 secondes 7 tierces. It is strange that a man should be clearsighted enough to invent such a function and yet be unable to devise a less clumsy notation. Indeed it would be almost incredible but for the relative frequency of such disparity. Compare for example NEWTON's awkward symbols for infinitesimals, and many other examples illustrated by FLORIAN CAJORI in his *History of mathematical notations* (2 vols., 1928-29, *Isis*, 12, 332-6; 13, 129-30).

STEVIN's decimal notation bad as it was was further aggravated by equivocation with his algebraical notation, for he used the same numbers within circles to express the different powers of the unknown quantity.

Thus 3(0)4(1)9(2) meant 3.49.

While $9(2) + 4(1) - 3(0)$ meant $9x^2 + 4x - 3$.

(7) See facs. p. 140. The last sign is a zero in the middle of a circle. In the course of this paper I am always replacing the circle with parentheses, simply for the printer's convenience and economy's sake.

In the second part he explains how the four fundamental operations may be legitimately extended to this new class of numbers. I need not insist upon this; the rules can be deduced from the examples given even without reading the text. However, it should be noted that STEVIN did not simply give rules but took the trouble to prove their validity, and thanks to his Greek training he did this rigorously.

Finally in an appendix (facs., pp. 149-60) the decimal idea is extended to moneys, weights and measures. I shall discuss that further on.

II. — PROGRESS OF DECIMAL NUMERATION

71. The *Thiende* was the earliest treatise deliberately devoted to the study of decimal fractions, and STEVIN's account was the earliest systematic account of them. Hence, even if decimal fractions were used previously by other men, it was STEVIN —and no other—who introduced them into the mathematical domain. That important extension of the idea of number—the creation of the decimal number—was undoubtedly a fruit of his genius, and its occurrence can thus be very exactly dated, —1585 (8).

To prove the truth of these statements and to help the reader appreciate the full value of STEVIN's *Thiende*, it is worthwhile to survey the development of decimal ideas before and after his time.

72. Examples of decimal numeration can be traced back in Egypt to the middle of the fourth millennium before Christ, when special symbols had already been created for a whole series of decimal units up to a million (9).

This is astounding but far less so then the realization that it took mankind four thousand years to go a little beyond this, and that, in spite of the fact that marvelous achievements were

(8) It is strange that in his fascinating book on *Number, the language of science* (1930, *Isis*, 16, 455-9) TOBIAS DANTZIG entirely overlooked the decimal stage.

(9) For these symbols see ALAN H. GARDINER : *Egyptian Grammar* (Oxford 1927, 191). The earliest example of their use is found on the great mace of king NARMER, who flourished about the beginning of the First Dynasty. That mace is now in Oxford. JAMES EDWARD QUIBELL : *Hierakonpolis* (vol. 1, pl. XXVI B, London 1900).

made during that very period by some of the greatest mathematicians of all times. Indeed the Greek system of numeration was distinctly inferior to the Egyptian, and the Roman was hardly above the Egyptian level.

73. What is stranger still, a " position " concept (10) was known to the Sumerians as early as the fourth millennium, but unfortunately it was imperfect and was mixed up with a kind of sexagesimal numeration.

Though the Sumerian system was gradually improved, the two magnificent ideas which it contained—position concept and extension of the integer scale to fractions—were jeopardized by their incompleteness. With regard to the position system, even in Babylonian times only the relative, not the absolute, magnitude of the units was indicated. There is no example of the use of a zero symbol before Seleucidian times, and even then it is only used in a median position, that is, the real size of the units remains undetermined. The second idea—subunits treated in the same manner as multiples—was spoiled by the same indetermination. Moreover the Sumerian numeration was not purely sexagesimal, but a compromise between the decimal and the sexagesimal systems (11).

The Mediterranean people who transmitted to us the ancient oriental culture were so little prepared to understand the " position " concept, that they allowed that part of the Sumerian invention to lapse while they preserved the sexagesimal idea, which was far less valuable.

74. The position concept reappeared in a better form in India at a time which cannot be determined (let us say in the early centuries of our era). Nor can it be known whether the

(10) That is, the value of a numerical symbol is made to depend partly upon its position with reference to others as in our own numeration.

(11) The history of that system has been admirably explained by THUREAU-DANGIN (1932). According to him (and I believe his interpretation is the correct one) the Sumerian sexagesimal system was the result of a spontaneous compromise : the very defectiveness of the base 10 with regard to divisibility causing the unconscious introduction of other bases such as 6 and 12, which were then empirically combined with the older base. There are other vestiges of such unconscious combinations, e.g., the Germanic terms *Schock* and *Grosshundert* meaning 60 and 120. The Sumerian combination occurred early enough—before the decimal base had developed beyond the stage of ten—and hence succeeded in establishing itself.

Hindu invention was independent or influenced by Babylonian examples. In any case, the Hindu position concept was combined with a purely decimal numeration, and that combination was truly a new invention,—one of great importance. Thanks to it every number can be unambiguously written with only ten different symbols (the nine numerals and zero).

75. In spite of its utter simplicity and usefulness many centuries were needed to incorporate this great discovery into our common knowledge, and the progress of the diffusion of the Hindu numerals was often interrupted by backslidings (12). These numerals and the new arithmetic which they symbolized were transmitted to us by Arabic writers, e.g., AL-KHWĀRIZMĪ (first half of ninth century) and AL-BĪRŪNĪ (first half of eleventh century), then by translators from Arabic into Latin, such as ADELARD OF BATH (first half of twelfth century) and by mathematicians, such as LEONARDO DA PISA (1202).

It is because of the Arabic transmission that these (our) numerals are generally called Arabic, but the Arabic speaking people call them to this day Hindu. For the false appellations Arabic and Jewish see my *Introduction* (2, 618). Byzantine authors called the new arithmetic Hindu (*ibidem*, 2, 973). The Hindu origin was not yet entirely forgotten at the beginning of the sixteenth century; e.g., the Venetian GIROLAMO TAGLIENTE remembered it (CANTOR 2^3, 305, 1900).

76. Even after the publication of LEONARDO's *Liber abaci* (1202) the new numerals were still very far from victory. As examples of the backslidings which slowed up their progress, let us consider the cases of AL-KARKHĪ in the East, and of RALPH OF LAON and the Alphonsine astronomers in the West (13).

ABŪ BAKR MUḤAMMAD AL-KARKHĪ of Baghdād (d. c. 1025) was one of the most distinguished algebraists of his time. He certainly knew the new numerals but in his arithmetic *(Kitāb al-kāfī fī-l-ḥisāb)* he did not use them at all and preferred the clumsy method of writing the numbers in full. However the Turkish historian ṢĀLIḤ ZEKĪ explains that this was due to the fact that AL-KARKHĪ composed the *Kāfī* (as he

(12) D. E. SMITH and L. C. KARPINSKI : *The Hindu Arabic numerals* (Boston 1911). SARTON : *Introduction* (2, 4-6).

(13) SARTON : *Introduction* (vol. 1, 718; vol. 2, 210, 837, 985).

states in his own preface) for common people (nās), the majority of whom were illiterate, in order to teach them the methods of mental calculus. He duly used the Hindu numerals in his algebra (14).

RALPH OF LAON knew the new numerals too but continued to use the old (Roman) numerals as well as the new. It is highly probable that the numerals used in the *Alphonsine Tables* (c. 1272) were Roman not Hindu in spite of the fact that the computers were thoroughly familiar with the latter: I suppose they considered the new numerals as part and parcel of the Arabic script and when they translated an Arabic text into Latin or Castilian they naturally replaced the Arabic numerals by Roman ones. In short, these people had failed to understand that the new numeration implied not simply a change of symbols but a change of principles.

77. The Hindu numerals became gradually better known in the fourteenth and fifteenth centuries. Their progress was not by any means straight and unencumbered but the result of a continued tussle between the old and the new, the latter gathering more strength—very slowly—as the years went by.

Good examples of the resistance to the new ideas are given by SMITH and KARPINSKI (1911, 133). Consider Germany: "German calendars of 1457-1496 have generally the Roman numerals, while KÖBEL's calendar of 1518 gives the Arabic forms as subordinate to the Roman. In the register of the Kreuzschule at Dresden the Roman forms were used even until 1539." They suggest (1911, 136) that the slowness of the diffusion was partly caused by the lack of cheap paper and pencils, and the backwardness of the methods of multiplication and division: all of which favored the use of counters instead of written numerals and thus minimized the practical value of a good system of numbers. The main cause of retardation, however, was the inertia of pedagogues, of which PROSDOCIMO DE' BELDOMANDI—writing as late as 1410— gave a remarkable instance at the beginning of his *Algorismus* (15).

(14) ṢĀLIḤ ZEKĪ: *Athār-i-bāqiya* (a history of Arabic mathematics, 2 vols. in Turkish, Istanbul, 1329=1911; *Isis* 19, 506-15).

(15) Printed in Padua 1483. D. E. SMITH: *Rara arithmetica* (1908, 13-15). SMITH and KARPINSKI (1911, 137).

A very elaborate survey of the early use of Hindu numerals in Europe was published by G. F. HILL in 1910. He examined a large number of manuscripts and objects of every kind and collected 870 examples : he tried to sweep into his net everything earlier than 1500 that came his way, but after that date the number of examples increased so much that he was obliged to exercise selection. From this we can at once conclude that the Hindu numerals cannot have been very popular before 1500 if a clever, learned and patient investigator such as HILL could only collect a few hundred specimens of their use.

78. After the introduction of the new system of numeration and of the new arithmetic that went with it, two arithmetical currents were noticeable in Western Europe. The two kinds of arithmeticians are sometimes called " abacists " and " algorists," a designation which would be excellent if the two terms (and their derivatives) had not been used promiscuously in many instances. The first of these terms referring to the ancient abacus suggests the old fashioned arithmetic; while the second one, derived from AL-KHWĀRIZMĪ's own name, represents the new arithmetic (16). Yet LEONARDO's book which was the main vehicle of the new ideas in the Latin West, was called *Liber abaci;* while the " *Algorismus* " of PROSDOCIMO DE' BELDOMANDI contained an outspoken denunciation of them ! The first printed arithmetic (Treviso, 1478) (17) was a true algorism using Hindu numerals as a matter of course. It was called " una practica " (a practical treatise) but we still find the words " larte de labbacho " at the end of the title. This promiscuous usage shows that minds were still befogged with regard to the main issue.

79. However, we may say that by the end of the fifteenth century the new numerals were well established in Western Europe, and that their diffusion continued gradually during the sixteenth century. By the end of that century the success of the new numerals and of the new arithmetic was almost complete and final, the old Roman numerals being kept only for ceremonial, formal or ornamental purposes.

(16) SARTON : *Introduction* (1, 756; 2, 4, and *passim* s. v. abacus, abacist, algorism, algorist).

(17) Elaborate analysis of it with facsimiles by D. E. SMITH (*Isis* 6, 311-31, 1924).

III. — Decimal fractions

Decimal fractions before 1585

80. Even as the Sumerians were the first to develop a kind of positional notation (the value of symbols depending on their position with regard to others), even so were they the first to think of using fractions the denominator of which was a multiple of their number base : in both cases the base was sexagesimal. But these two great inventions were impaired by the lack of a symbol for zero (18), and by the lack of consistency. In the course of time the sexagesimal base disappeared, but strangely enough the sexagesimal fractions remained,—and will probably remain forever an integral (though inconsistent) part of our own system of knowledge.

The decimal system of numbers and the sexagesimal system of fractions developed parallelly for thousands of years. The fact that even the best mathematicians of the Middle Ages did not think of decimal fractions in spite of their familiarity at one and the same time with decimal numbers and with sexagesimal fractions simply proves that they had not yet grasped the decimal idea in its fulness, and no wonder considering how slow they were in apprehending it at all.

81. This misunderstanding may be partly explained by the fact that for a long time sexagesimal fractions were not truly conceived as fractions. For example, Ptolemy states in the Almagest that he will employ the sexagesimal system in order to avoid fractions (19) : in the same way the Roman or English divisions of the pound are not generally thought of as fractions. The Roman speaking of " septunx " or the Englishman speaking of " seven ounces " are not thinking of the pound but only of ounces.

(18) The zero was a later introduction, possibly by a Babylonian (as opposed to Sumerian) astronomer, and at first was only used in a median position, as explained in § 73.

(19) *Καθόλου μέντοι κρησόμεδα ταῖς τῶν ἀριθμῶν ἐφόδοις κατὰ τὸν τῆς ἑξηκοντάδος τρόπον διὰ τὸ δύσχρηστον τῶν μοριασμῶν* (1, 10; Heiberg p. 32). By *μοριασμός* Ptolemy meant the Egyptian type of fractions.

However, later on the true fractional nature of the sexagesimals was recognized, witness the name *minutiae physicae* or *minutiae philosophicae* applied to them as opposed to the name *minutiae vulgares* applying to the ordinary fractions.

From the time of the Greeks on the sexagesimal system was used only for submultiples, not for multiples. A remarkable exception to this occurs in the Alphonsine Tables, where sexagesimal multiples were actually used and that usage was followed by a few authors of the end of the sixteenth century, (20) then disappeared : such freakish exceptions concern the archaeologist rather than the historian of science.

82. The earliest suggestion of decimal fractions I know of is found in the *Mishnat ha-middot*, a Hebrew treatise the dating of which is uncertain. Its latest editor, SOLOMON GANDZ, would ascribe it to Rabbi NEḤEMIAH and thus place it about the middle of the second century of our era (21).

We read in § 8 of chapter I (GANDZ, p. 22) :

" Ten upon ten are amounting to a hundred. The half of ten is five. Five times five are twenty and five, and this is the fourth of 100. And the position of the 10 is in the 1, and the position of the 100 in the 10, and of the 1000 in the 100. From now on go ahead and figure with the fractions according to the measure of the units. But with the units it is increasing and with the fractions it is decreasing."

83. That suggestion was too obscure to be fertile, but the Persian mathematician ABŪ-L-ḤASAN 'ALĪ IBN AḤMAD AL-NASAWĪ (first half of eleventh century) (22) indicated a path which led eventually to the notion of decimal fraction.

To find the square root of $26^{0}17'$ he proceeds as follows :

$$\sqrt{26^{0}17'} = \frac{1}{60}\sqrt{94620^{0}} = \frac{1}{60}307^{0} = 5^{0}7'$$

but to find the square root of 17^{0} he does this :

$$\sqrt{17^{0}} = \frac{1}{100}\sqrt{170000^{0}} = \frac{1}{100}412^{0} = 4^{0}7'12''$$

(20) L. SCHOENER (1586), PAUL REESEN (1587), RAYMARUS URSUS (1588) : all post-Stevinian ! After TROPFKE (1^{3}, 1930, 61-4).

(21) SARTON : *Introduction* (2, 208-9). SOLOMON GANDZ : *The mishnat ha-middot* (96 p., 4 pl., Berlin 1932; *Isis* 20, 274-80).

(22) *Introd.* (1, 719). H. SUTER : Über das Rechenbuch des 'ALĪ BEN AḤMED EL-NASAWĪ (*Bibliotheca mathematica*, 7, 113-9, 1906).

The same method of extraction of square roots

$$\sqrt{a} = \frac{1}{10^n}\sqrt{(a.\ 10^{2n})}$$

is also explained in the *Liber alghoarismi de practica arismetrice*, the Latin translation of an unknown Arabic original by JOHN OF SEVILLE (23) (fl. Toledo c. 1135-53), and in the *Demonstratio de minutiis* by JORDANUS NEMORARIUS (first half of thirteenth century), which includes the following example

$$\sqrt{26} = \frac{1}{100}\sqrt{260000} = 5^{\circ}5'24'' \text{ (24)}$$

[84. It would seem that the great Chinese mathematician YANG HUI (fl. c. 1261-75) made use of decimal fractions to replace complex numbers by simple ones, but I know the relevant text only through MIKAMI's interpretation of it, and in any case that Chinese contribution did not influence the development of the decimal idea in the West.] (25).

85. To return to the West, a remarkable advance was made by the Parisian astronomer, JOHN of MEURS of Lisieux in the *Quadripartitum numerorum* which he composed c. 1343. In chapter 22 of the second book he extracts the square root of 2 using the method which we have just mentioned

$$\sqrt{2} = \frac{1}{1000}\sqrt{2.000.000} = \frac{1}{1000}\,1414$$

He states the result in sexagesimal terms $1^{0}24'50''24'''$ but then adds that if we say that 1414 is the root of 2 the first unit of that number is to be regarded as an integer, the following 4 as tenths, etc. (26). This is very remarkable indeed to us

(23) B. BONCOMPAGNI : Trattati d'aritmetica, II (Rome 1857). SARTON : *Introd.* (2, 169). The Arabic original is very probably anterior to AL-NASAWĪ, even if it is not quite as early as AL-KHWĀRIZMĪ (first half of ninth century). It should be noted that the method which I shall call AL-NASAWĪ's, i.e., $\sqrt{a} = \frac{1}{10^n}\sqrt{(a.\ 10^{2n})}$ was already used but only in its sexagesimal form by the BANŪ MŪSĀ IBN SHĀKIR, younger contemporaries of AL-KHWĀRIZMĪ. H. SUTER : Über die Geometrie der Söhne des MŪSĀ BEN SCHĀKIR (*Bibliotheca mathematica*, vol. 3, 259-72, 271, 1902).

(24) TROPFKE (1^{3}, 173).

(25) *Introduction* (2, 1023). Y. MIKAMI : *The development of mathematics in China and Japan* (Leipzig 1913, 86).

(26) L. C. KARPINSKI : The decimal point (*Science* 45, 663-5, 1917). KARPINSKI quotes the relevant Latin passage.

who know—but JOHN OF MEURS was obviously so much ahead of his time that his saying far from being considered remarkable by his contemporaries remained unnoticed. They should not be blamed for this, for the guilt was partly his own. He stopped short of the goal : he might have discovered the idea of decimal fraction but he just failed to do so.

Hence for a long time the same kind of misunderstanding continued. The German JOHANN VON GEMUNDEN (d. 1442) extracted square roots according to AL-NASAWĪ's method. He began by expressing sexagesimal numbers in terms of the lowest sexagesimal unit; then if necessary magnified them on a decimal base; the result was retranslated into sexagesimal terms. This method might be expressed as follows

$$\sqrt{a} = \frac{1}{60^n 10^m} \sqrt{a\, 60^{2n} 10^{2m}}$$

The confusion due to a simultaneous use of a decimal base and of a sexagesimal one appears here very clearly. Mathematicians realizing it, and realizing also the impossibility of rejecting completely the one base or the other, tried unconsciously to combine both. However, the final result had to be expressed in one way or another : JOHANN VON GEMUNDEN expressed it in sexagesimal terms; a later mathematician, PAUL OF MIDDELBURG (1445-1533), expressed it occasionally in decimal terms, e.g., duos cum minutiis 8561 de partibus 10000 (meaning 2.8561) (27).

86. One of the earliest examples of a true decimal fraction was given by GHIYĀTH AL-DĪN JAMSHĪD IBN MAS'ŪD (d. 1436-7), first director of the observatory founded by ULŪGH BEG in Samarquand, in his treatise *Al-risāla al-muḥītīya* dealing with the ratio of diameter to circumference, the value of what we would call 2π being quoted as 6.28318... a result correct to 16 decimal places. JAMSHĪD separated the fractional from the integral part by writing the word ṣaḥāḥ on the top of the latter (28).

87. JOHANN VON GEMUNDEN's famous pupil GEORG PEURBACH

(27) In his very interesting book *De numero atomorum totius universi contra usurarios* (Rome 1518). Quoted by D. J. STRUIK : Sull'opera matematica di PAOLO DI MIDDELBURG (*Rendi conti d. R. Acc. dei Lincei*, sci. fis., serie 6, 1, 305-8, 1925).

(28) H. SUTER : *Die Mathematiker der Araber* (1900, p. 173). SMITH (1923, 1, 190). ṢĀLIḤ ZEKĪ : *Athār-i-bāqiya* (2 vols. Istanbul 1329; *Isis* 19, 512).

(1423-1461) wrote a *Tractatus super propositiones* PTOLEMAEI *de sinubus et chordis* (printed Nuremberg, 1541) containing tables of sines. The sines were computed with reference to a radius of length 600.000. This artifice was in all probability suggested by the similar one used in the extraction roots. The aim was to avoid fractions.

The same artifice was used in the *Tabula directionum*, which PEURBACH's disciple REGIOMONTANUS (1436-1476) computed in Rome in 1467 (29), but the latter had the courage to return to a decimal base, the tang. 45° or radius being equalled to 100.000. This was deliberate, REGIOMONTANUS explaining in the introduction the material advantage which was thus gained in the computations (29*bis*). And yet he computed a later table on the base of a radius equalled to 6.000.000.

88. To these western tables may be added the *decimal* (not sexagesimal) tables of sines and tangents included in the *Kharīdat al durar* of TAQĪ AL-DĪN MUḤAMMAD IBN MA'RŪF, who founded the first observatory in the Ottoman empire and died in 1585-86 (30).

89. A strange survival of that trick—the use of a large number as unit in order to avoid fractions—is found as late as 1662 in THOMAS WILLSFORD's appendix to that year's edition of ROBERT RECORDE's *Ground of artes* (31): WILLSFORD reckons interest " to the radius 100.000 " ! (32)

90. Another stream of thought—closely connected with the preceding one—developed presumably in Italy, in the fifteenth century. We find the first trace of it in a long letter addressed by REGIOMONTANUS to GIOVANNI BIANCHINI, dated Venice 1463 (33). Soon after this it was explained didactically by

(29) Printed, Augsburg 1490. For GEMUNDEN, PEURBACH, REGIOMONTANUS, see CANTOR (II², 1900, 178, 182, 275).

(29bis) There is a curious discussion of this in STEVIN's Geography (*Hypomnemata*, vol. 1, part 2, p. 12, 1605).

(30) H. SUTER : *Die Mathematiker der Araber* (1900, p. 191). ṢALIḤ ZEKĪ : *Athār-i-bāqiya* (2 vols., Istanbul 1329; Isis 19, 509).

(31) First printed c. 1542.

(32) SMITH (1910, 14).

(33) MAXIMILIAN CURTZE : Der Briefwechsel REGIOMONTAN's mit GIOVANNI BIANCHINI, JACOB VON SPEIER und CHRISTIAN RODER (*Abhdl. zur Gesch. der mathem. Wiss.*, Heft 12, Leipzig 1902, see p. 202, 225). In his *Practica arithmeticae* (Milano 1539) CARDANO called it " REGIOMONTANUS' rule."

two Italians—BORGHI and PELLIZZATI—and by the German CHRISTOFF RUDOLFF.

In his *Arithmetica* (pr. Venice, 1484) PIETRO BORGHI (34) shows that to divide a number by $a.10^n$, one cuts off n figures starting from the right of that number, and divides the remaining figures by a.

For ex., to divide 2345678 by 3000, one separates the three figures at the right and divides the four remaining ones by three. The quotient is 781 and the rest 2; the final result, $781\frac{2678}{3000}$.

The same method is explained by FRANCESCO PELLIZZATI (or PELLOS) (35) in his *Art de arithmeticha* printed at Turin 1492, and by CHRISTOPH RUDOLFF in his algebra named *Coss* of 1525. These authors were blinded by an equivocation between the decimal idea and the ordinary process of division. If they had been capable of a little more abstract thinking they might have discovered the decimal fractions, but they were not.

91. PELLIZZATI's *Art de arithmeticha* of 1492 seems to offer the earliest printed examples of decimal dots, but that is only an appearance for his dots are not real decimal dots and his understanding of the matter was very ambiguous.

There are plenty of "false decimal dots" in early Mss. For example, large numbers were often separated by dots (or commas) in smaller groups of figures: the very needs of writing, reading, and checking would naturally lead to that. Better than that, in NICOLAS CHUQUET's *Triparty* (1484; only printed in 1880) integers are enclosed between two dots. For example, CHUQUET says that to divide .503. by .10. one writes $.50.\frac{3}{10}$ (36.)

92. RUDOLFF came nearer to the decimal fraction than I have indicated above, in a later book of his, the *Exempel Büchlin* (Augsburg 1530) wherein he introduced a symbol to separate the fractional from the integral part of a number. He used that symbol—a vertical stroke—as we use the decimal point, yet without realizing its generality and pregnancy. See figs. 43-44.

D. E. SMITH remarks (1910, 16) "If one man were to be

(34) CANTOR (II² 1900, 305). SMITH (1908, 16). BORGHI died after 1494.

(35) For PELLIZZATI see SMITH (1908, 50-52); for RUDOLFF, CANTOR (II² 1900, 399), SMITH (1908, 151, 159), CAJORI (1928, 316).

(36) SMITH (1910, 14).

named as the best entitled to be called the inventor of decimal fractions, RUDOLFF might properly be the man." I cannot agree with this: RUDOLFF's invention was purely intuitive; something more is needed to complete a scientific, and above all a mathematical, invention. It is not enough to stumble on something; the inventor cannot be recognized as such until he has justified his invention and proved his full understanding of it and of at least some of its implications.

Strangely enough RUDOLFF's symbol of decimal separator was used at the same time—or rather a little before RUDOLFF—by the Jewish mathematician ELIJAH BEN ABRAHAM MIZRAḤI (born at Constantinople c. 1455, died there in 1525 or 1526) in his *Sefer ha-mispar*, printed posthumously in Constantinople, c. 1532 (37). MIZRAḤI used that symbol while converting sexagesimal fractions into decimals. See figs. 45-46.

The fact that some kind of decimal symbol was used independently in two places as distant (physically and morally) as Augsburg and Constantinople is significant: the idea was slowly maturing.

In spite of its publication in a Hebrew book MIZRAḤI's notation exerted some influence on western arithmetic. Indeed the Italian mathematician GIOVANNI ANTONIO MAGINI (1555-1617) (38) made use of a comma (" virgula ") as a decimal separator in his work *De planis triangulis* (Venice, 1592), and he explained how to convert decimal fractions (fractiones secumdum denariam rationem) into sexagesimals, referring to ELIJAH MIZRAḤI as the inventor of that method.

93. MAGINI's book takes us even beyond the time of STEVIN's *Thiende*, but we must still mention one other book anterior to it, namely VIÈTE's *Universales inspectiones* appended to his *Canon mathematicus* (Paris, 1579) (39), wherein decimal fractions are quite clearly written: the fractional part printed in smaller type than the integral one and separated from the latter by a vertical stroke. What is perhaps even more important,

(37) GINSBURG (1932, 169). With regard to the use of a perpendicular bar as separator between integers and fractions there was a well established tradition in Hebrew writings. LEVI DEN GERSON (d. 1344) and MORDECAI COMTINO (d. 1482) both used it for sexagesimals. PINCUS SCHUB: A mathematical text by M. COMTINO (*Isis* 17, 54-70, 1932, see p. 65).

(38) GINSBURG (1932, 84-85, 168-9).

(39) CANTOR (III² 1900, 583). CAJORI (1928, 316).

in the *Canon mathematicus*, VIÈTE, renounced sexagesimal fractions in favor of decimal ones.

STEVIN's *achievement of* 1585

94. My account of decimal fractions before STEVIN is more than sufficient I believe to prove two things: first that the idea was "in the air" in the sixteenth century; second, that in spite of the fact that many mathematicians had hovered around it none, excepting perhaps VIÈTE, had grasped it clearly and completely. There are many examples of decimal fractions before 1585 yet no formal and complete definition of them, not to speak of a formal introduction of them into the general system of numbers.

This was done by STEVIN and, but for his notation which need not have been as clumsy as it was, his achievement was as near perfection as it could be in his time. This alone would establish the singularity of his genius, even if one does not take into account the prophetic appendix (facs., pp. 149-60) which will be the subject of a separate discussion. For the present we leave the appendix out and deal only with the book itself.

By STEVIN's time various aspects of the decimal idea had become trivial: decimal magnification of numbers for root extraction; decimal magnification (10^n or 6.10^n) of the radius for the calculation of trigonometrical ratios; even decimal notations, yet nobody had seen the inner relationships of these things, nobody had become aware of the single reality which they represented. Among the earlier authors the one who had come nearest to the truth was the Frenchman, JOHN OF MEURS, in his *Quadripartitum*, but that was a flash of genius which if it had ever been noticed, had long been forgotten. The *Quadripartitum* was composed c. 1343 and was known only in manuscript.

In the *Thiende* the idea is set forth completely and with the utmost lucidity. STEVIN's deep grasp of it is evidenced from the very beginning. Indeed in the very first definition he announces that the *Thiende* is a new kind of arithmetic by means of which all accounts and measurements can be completed without fractions. That is, as soon as our fractions are put in the decimal

form—are placed in the very frame of our number system—they disappear.

The mathematicians who multiplied their trigonometrical unit by 10^n had been unconsciously aware of this, but STEVIN was perfectly conscious and his very first definition expressed the fundamental idea of the new arithmetic in its plenitude.

We shall appreciate STEVIN's achievement even better if we realize that his masterly expansion of the decimal idea was the first deliberate and clear synthesis of the Sumerian conception of a base extended to submultiples as well as to multiples together with the Hindu principles of numeration. How slow and devious the ways of human discovery, and how long it takes even the most intelligent of us to draw the simplest deductions, unless somebody (in this case STEVIN) is blessed with an intuitive revelation of them!

It is true his magnificent boldness failed him when he devised his symbolism: He had understood that any decimal fraction was identical to an integer but for a decimal coefficient,—and thus it would have sufficed to indicate that coefficient in one way or another in order to distinguish that particular fraction from the integral matrix. In spite of which he introduced a cumbersome set of notations, defining separately each decimal subdivision!

How did it happen? I think one can reconstruct the genesis of his symbolism in the following way. Let us consider again the example which he gives in his third definition (see facs., p. 140). Says he

" 8(0)9(1)3(2)7(3) vallent $8\ \frac{9}{10}\ \frac{3}{100}\ \frac{7}{1000}$ ".

Let us write this more explicitly

$$8\ (\tfrac{1}{10})^0,\ 9\ (\tfrac{1}{10})^1,\ 3\ (\tfrac{1}{10})^2,\ 7\ (\tfrac{1}{10})^3,$$

then let us cancel the repetitious $(\frac{1}{10})$, and let us agree to represent $(\frac{1}{10})^n$, by (n) (40).

This shows that STEVIN's decimal notations were really decimal exponents, and explains if it does not justify, the ambiguity which he permitted to exist between his decimal and his algebraical symbolisms.

(40) I repeat that STEVIN's notation is really n in a circle instead of n between parentheses (see facsimile). Hence the convention is " n in a circle means $(\frac{1}{10})^n$ ".

This was all right but shockingly redundant. It is distressing to witness in this case as in many others the sharp limitations of human genius. STEVIN's notation brings to our mind the early Egyptian symbols: even as the Egyptians thought it necessary to have a separate symbol for each decimal multiple, so did STEVIN think that a separate symbol was needed for each decimal submultiple. It is true STEVIN's notation was immeasurably better than the Egyptian because of its exponential feature: his symbols were connected and expressed their exact relationship. On the other hand, this multiplicity was less excusable than the Egyptian one, for in the meanwhile the discovery of the principle of position and of the zero had cancelled its necessity.

It should be noted that in the actual calculations STEVIN's symbols were a little less cumbersome than they seem at first glance, for if many decimal numbers were handled together—for example, in a multiplication—it sufficed to indicate each symbol once and for all at the top or bottom of its respective column (see facsimile), and of course the computer would soon learn to write only one of them for his own usage, adding the others only in case of publication. Such a notation if it were adopted by many people would gradually simplify itself, yet we shall see in the following section that simple decimal notations were exceedingly slow in shaping themselves.

STEVIN improved considerably his own notation in his Geometry (1605); however, this was hardly noticed by his contemporaries. For example (41) he says that the square root of 50 is 707(2); meaning 7 and two decimals ($7\frac{7}{100}$). From the indication of the number of decimals by a figure to its indication by a point or comma would seem to be but a little step, yet how long it took to make it,—that is, to make it well and for ever!

STEVIN is truly the discoverer of decimal fractions: he defined them completely and clearly, proved the validity of their use in almost the same way as if they were integers, and extended the arithmetical structure enough to include them.

(41) *Hypomnemata* (vol. 2, 99, 1605); or in GIRARD's *Œuvres* (2, 390).

The decimal fractions after 1585

95. I have no intention of writing a complete history of the decimal fractions after STEVIN—this would involve almost the whole of elementary arithmetic—but simply to give enough information on the subject to complete my demonstration of STEVIN's genius. I gave a first proof of it when I showed how he did in 1585 what so many brilliant men had failed to do before him; I shall now give another proof of it by showing how slow was the progress after him in spite of the tremendous impetus which he had given.

From 1585 *to* 1600

96. I have already referred to the use of a " virgula " as decimal separator by GIOVANNI ANTONIO MAGINI in his *De planis triangulis* (Venice 1592). MAGINI also speaks of a decimal notation (denaria ratio) (42).

In the same year THOMAS MASTERSON published his *First booke of arithmeticke* (London 1592) wherein a vertical bar is used as a decimal separator. (43)

The Jesuit father, CHRISTOPHER CLAVIUS, made use of a point as a decimal separator in the sine tables included in his treatise on the astrolabe, *Astrolabium* (Rome, 1593) (44). However, his real grasp of that notation is open to doubt and the more so because in the Algebra which he published fifteen years later (Rome, 1608) he wrote all decimal fractions in the form of common fractions.

In his *Arithmetica* completed some time after August 1592, the Swiss JOOST BÜRGI put a zero under the last integral figure to serve as a decimal separator. $14\overset{\circ}{1}4$ (meaning 141.4). This would hardly deserve to be noticed because BÜRGI's *Arithmetica* remained unpublished and its date is uncertain, but for the fact

(42) GINSBURG (1932, 84-85).

(43) SMITH (1908, 400-3). CAJORI (1928, 316). The development of decimal notations has been described with an almost painful elaborateness by CAJORI (1928, 314-35).

(44) GINSBURG (1928). CAJORI (1928, 322).

that KEPLER ascribed the new kind of decimal computation to BÜRGI, not to STEVIN ! (45)

That is all I can find for the end of the sixteenth century and how pitifully little it is as compared with STEVIN's *Thiende*.

From 1601 *to* 1625

97. In 1603, JOHANN HARTMANN BEYER (46) (1563-1625), state physician of Francfort a.M. (Reipublicae Francofurtensis medicus) published (1) ***Ein newe und schöne Art der Vollkommenen Visierkunst : Derengleichen hiebevor niemaln in keiner Spraach gesehen worden...*** (Francfort a.M., 1603) 191 p., dedic. Sept. 12, 1603 (fig. 33). The first chapter on p. 1 bears the following title : " Was für Zahlen bey dieser Visierkunst gebraucht werden : nemblich nuhr gantze und zehende vielfaltig continuirte Brüche. Auch wie dieselbige zu schreiben, zu bezeichnen und zu lesen oder auszusprechen."

In the same year BEYER published a similar book in Latin, namely his (2) ***Stereometriae inanium nova et facilis ratio, geometricis demonstrationibus confirmata*** (Francfort, 1603) 267 p., dedic. Sept. 14, 1603 (fig. 34). Chapter 1 on p. 1 is entitled " De notatione numerorum stereometricorum, ex integris decimisque scrupulis mistorum."

The items (1) and (2) are different treatments of the same subject by the same author. Note that the dates of dedication follow each other closely : Sept. 12 and 14. The same blocks

(45) KEPLER : *Ausszug auss der uralten Messe-Kunst Archimedis*, or, *Oesterreichisches Wein-Visier-Büchlein* (Linz, 1616), reprinted in KEPLERI *opera* (ed. CH. FRISCH, vol. 5, 497-613, see p. 547). CANTOR (II² 1900, 618). KARPINSKI (1917, 664).

(46) I have been obliged to rewrite the part dealing with BEYER on the basis of new information generously provided by Prof. Dr. J. TROPFKE, who examined BEYER's publications (none of which was available to me) in the *Preussische Staatsbibliothek* for me, and sent me photostats of the titlepages and of some other significant pages. Thanks to Prof. RUSKA's courtesy these photostats were made for me at the *Institut für Geschichte der Medizin und der Naturwissenschaften* attached to the University of Berlin.

Before knowing the results of the investigations so kindly made by Prof. TROPFKE at my request, I thought that the *Logistica decimalis* had first appeared in 1603, and that the edition of 1619 was a second edition. See CANTOR (2, 619, 1900), CAJORI (1928, 314), TROPFKE (1³, 180, 1930).

were used for the illustrations, but the substance, examples, and order are different.

Some sixteen years later BEYER published three more items (3) *Logistica Decimalis: Das ist: Kunstrechnung der Zehentheyligen Brüchen* (fig. 35), 230 p., dedic. July 10, 1619. This is the book which has been quoted by historians thus far (CANTOR, TROPFKE, CAJORI) as the source of his decimal ideas. It is true it deals with the same subject as items (1) and (2), yet it is as incorrect to call it a new edition of (1) as to consider (2) a translation of (1). It is a new book including many elements of the old (many examples are the same in 1 and 3). We may say that BEYER published his decimal ideas for the first time in 1603, but we cannot say that the *Logistica decimalis* dates from that year.

Before discussing the *Logistica* let us consider the two other publications of 1619-1620 (4) *Conometria Mauritiana; Das ist Ein newer Stereometrischer Tractat...* (Francfort, 1619), 125 p. (fig. 37).

(5) *Kurtzer Bericht Von Zubereytung einer Visier-Ruthen auss einem geeichten Weinfass... Zu Erläuterung des* 28. *Capituls seiner Visierkunst; und* 4. *Capituls Conometriae Mauritaniae* (Francfort, 1620), 6 p.

The *Logistica decimalis* of 1619 had the advantage of a clear title revealing at once the new fundamental idea. This was not the case for the two books of 1603. The title of 1619 was significant but STEVIN's title of 1585 "*De Thiende*" was even more challenging and impressive because of its greater simplicity (compare figs. 31 and 33).

Did BEYER know STEVIN's work anterior to his by eighteen years? As far as I can judge (for I have not seen the whole of his works) he does not mention STEVIN. According to the title of his first book, the *Visierkunst*, "the like of it has never been seen in any language"—but that boastful statement may refer to another feature of the book.

The first chapter of the *Logistica decimalis* (pp. 22-23) is entitled "Was die Mechanische Kunstrechnung sey: Und wie sie erfunden" (fig. 36). The "mechanische Kunstrechnung" is BEYER's German translation of "decimal calculation," "Die Mechanische Bruchrechnung wird Logistica decimalis, *Δεκαρίθμησις*

genandt." The name " mechanical calculation " was not a bad slogan for it emphasized the almost mechanical convenience of decimal fractions as compared with others. This chapter devoted to the definition and history of the decimal idea, contains no reference to STEVIN. BEYER states that the idea first occurred to him in 1597 when he became interested in mathematics. The consistent use of sexagesimals by astronomers suggested to him the consistent use of decimals, which would be easier (but apparently he did not see that the main superiority of the decimals lies in their consistency with our number system; STEVIN had seen that in 1585) (46*bis*).

On the other hand his nomenclature is strikingly similar to STEVIN's. His names for the successive decimals " Primen, Secunden, Terzen " are equivalent to STEVIN's " Primes, secondes, tierces." His notation was very similar to STEVIN's also (he put Roman figures above the successive decimals I, II, III, etc.) but he introduced an awkward and perilous simplification, writing

$$8.\overset{\text{V}}{798} \text{ for } 8\frac{798}{10^5}$$

Moreover his *Conometria Mauritiana* was thus named after Prince MAURICE of Orange (fig. 37), and is it conceivable that he would have known of that prince well enough to name a book after him and that he would not have known of the prince's most illustrious mathematician? Hence it seems certain to me that BEYER knew of STEVIN's work in 1619; it is probable that he knew of it already in 1603.

In the English translation (1608) of the *Thiende*, ROBERT NORTON replaced the circles surrounding the Stevinian exponents by parentheses, even as we do in this paper and probably for the same reason : typographical expediency.

In his *Trigonometria* (editions of 1608 and 1612, not before) BARTHOLOMEW PITISCUS used decimal points. There has been

(46bis) At the end of his historical account, BEYER states clearly the relationship of his third book to the first two " Darauff ich ferner diesem Werck embsig nachgedacht und die gantze Mechanische Bruchrechnung in gewisse Reguln und praeccpta Notationis, Numerationis und Extractionis radicum, verfasset : Auch dieselbige auff etlicher Kunstliebenden anhalten Anno 1603, in offenem Truck neben der Visirkunst, Teutsch und Lateinisch, publicirt. Welche ich nunmehr revidirt, verbessert mit nützlichen Exempeln gemehret und also diese ganze δεκαρίθμησιν mercklich erläutert und erleichert hab."

much discussion as to whether he was the first to use them or not. Much of that is now of secondary interest, because we know earlier instances of the use of decimal separators, quoted above. Moreover, his tables were computed with reference to a radius 10^n (n having different values in different tables according to need) and the numbers appearing in them are integers, not fractions. As these numbers are very large they are divided by dots into smaller groups and in various ways for the sake of legibility : this was an old practice. Examples :

Table of 1612, sec $3'' = 100000.00001.06$ (integer).

Table of 1613, *(Thesaurus mathematicus, sive Canon sinum)* sine $2^0 52' 30'' = 5015.71617.47294$ (integer).

To be sure PITISCUS was aware of decimal fractions and he occasionally used decimal separators, but his use of them lacked consistency; it was occasional, not systematic (47).

On the other hand KEPLER understood the decimal calculus very well and in the *Wein-Visier-Buchlein* (Linz, 1616) above-mentioned he used a simple notation,

$$3(65 \times 6 = 21(90$$

but he ascribed the invention of that calculus to BÜRGI. BÜRGI himself used another notation, inferior to KEPLER's, in his *Progress-Tabulen* (Prag, 1620) : he placed a little zero above the last figure of the integral part.

However, the main introducer of decimal fractions into common practice was NAPIER (1550-1617) not only because his clear understanding of them (not clearer than STEVIN's or KEPLER's), but also because the new mathematical instrument invented by him became incidentally the best vehicle of the decimal idea.

In his *Rabdologia* (Edinburgh, 1617) and even better in his *Constructio* written before but published posthumously, in appendix to the third edition of the *Logarithmorum canonis descriptio* (Edinburgh, 1619), NAPIER expresses that idea in the simplest manner. In section 5 of the *Constructio* he states " Whatever is written after the period is a fraction." At last we know exactly where we are. The fact that in the *Rabdologia* he still used a poor notation reminiscent of sexagesimal fractions may be forgotten. In the *Constructio* his decimal notation is absolutely unambiguous.

(47) For PITISCUS see CANTOR (II, 1900, 604, 619). KARPINSKI (1917, 663). Long discussion in CAJORI (1928, 317-22).

Whether NAPIER knew the works of PITISCUS or not is of no importance for he did not need them. The decimal calculus had been admirably explained by STEVIN, and decimal separators had been used before PITISCUS and with less ambiguity (48).

The invention of common logarithms by NAPIER and HENRY BRIGGS was a tremendous enrichment of the decimal idea. In that sense the history of common logarithms is an essential part of the history of the decimal calculus, yet we cannot consider it here. It will suffice for our present purpose to recall that the first table of common logarithms of trigonometric ratios was published by EDMUND GUNTER in London 1620, and the first table of common logarithms of numbers by HENRY BRIGGS in London 1624.

A few remarks on the period 1625-1700

98. The publication of tables of common logarithms influential as it was did not consecrate the final triumph of the new arithmetic. One must bear in mind that the logarithms remained for a long time outside of the domain ruled by the ordinary schoolmasters and writers of mathematical treatises.

A German writer of 1629, WILHELM VON KALCHEIM, alias V. LOHAUSEN (1584-1640): *Zusamfassung etlicher geometrischen Aufgaben*, Bremen 1629 (fig. 40), writes 693 (2) for 6.93. (Same notation as in STEVIN's geometry, 1605, see § 94.)

Decimal fractions were well explained by a number of seventeenth century writers, for example, WILLIAM OUGHTRED in his *Clavis mathematicae* (London, 1631), PIERRE HÉRIGONE in his *Cursus mathematicus* (6 vols., Paris, 1634 sq.), ANDRÉ TACQUET in his *Arithmeticae theoria et praxis* (Louvain, 1656) (49). Father TACQUET called them *numeri decimales*. According to him the two main authors of arithmetical progress are STEVIN and NAPIER,—a good judgment for one so near to the events. On the other hand he had not yet been able to emancipate himself from

(48) For discussion on this subject see GRAVELAAR (1900), KARPINSKI (1917), CAJORI (1928, 322-4).

(49) BOSMANS (1927; *Isis* 9, 79-80). For other seventeenth century textbooks see TROPFKE (I^2, 181).

STEVIN's redundant notation, and not only that but he sometimes added a decimal dot to it !

We may still mention the *Cursus mathematicus seu absoluta omnium mathematicarum disciplinarum encyclopaedia* (Würzburg, 1661; Francfort, 1674) of KASPAR SCHOTT wherein the decimal numbers are called *numeri geometrici* (50).

For another example we may turn to SMITH's precious book *Rara arithmetica*. The astrologer, HUMPHREY BAKER (fl. 1562-87), published in London 1568 the " *Well-spryng of sciences*, " an arithmetical treatise which was astonishingly successful: it was reprinted in 1574, 1580, 1583, 1591, 1598, 1602, 1612, 1617, 1631,... 1659, 1687. Decimal fractions appeared for the first time in the edition of 1659, wherein one may read (according to SMITH, p. 329) the following statement :

" The Fractions [in the tables at the end of the book] which before were in the common way (and so the figure being small in many not discerned) are put into the decimal parts, and so the same with the integral, but farre more true than the Common Fractions can express it in one figure, and if in the common it be exprest in many, (as it must be, if true) then the decimal is far more easie, because the Denominator is one and the same to all, whereas the other is differing."

The knowledge of decimals exhibited in that edition—which appeared seventy four years after STEVIN's *Thiende* and more than half a century after the English *Disme*—is very slight. This part of the book is much improved in the edition of 1687 (51).

I have mentioned above Father TACQUET's redundant way of writing decimals. Another kind of redundance was practised by FRANZ VAN SCHOOTEN in his *Exercitationes mathematicae* (Leiden, 1657): he wrote 638,82(2). STEVIN's notation was used as late as 1691 by JACQUES OZANAM : *L'usage du compas de proportion* (La Haye, 1691). Other examples of similar tautologies will be found in CAJORI (1928), who quotes (p. 326) a very interesting statement made by the Puritan antiquary SAMUEL JEAKE (1623-90) in the *Λογιστικηλογία or Arithmetic surveighed and reviewed* edited by his son, SAMUEL JEAKE, JR., the astrologer, and published in London 1696 (fig. 42). This is such a good summary of the decimal confusion at the end of the seventeenth century that I requote it in extenso.

(50) TROPFKE (I^3, 182).
(51) SMITH (1908, 327-30).

" For distinguishing of the Decimal Fraction from Integers, it may truly be said, *Quot Homines, tot Sententiae;* every one fancying severally. For some call the Tenth Parts, the *Primes;* the Hundredth Parts, *Seconds;* the Thousandth Parts, *Thirds*, etc. and mark them with *Indices* equivalent over their heads. As to express 34 integers and $\frac{1426}{10000}$ Parts of an Unit, they do it thus, $34\cdot{}^{\prime}1.{}^{\prime\prime}4.{}^{\prime\prime\prime}2.{}^{\prime\prime\prime\prime}6.$ Or thus, $34.\ {}^{(1)}1\ .\ {}^{(2)}4\ .\ {}^{(3)}2\ .\ {}^{(4)}6\ .$ Others thus, $34{,}1426^{\prime\prime\prime\prime}$; or thus, $34{,}1426^{(4)}$. And some thus, 34.1.4.2.6. setting the Decimal Parts at little more than ordinary distance one from the other... Others distinguish the Integers from the Decimal Parts only by placing a Cöma before the Decimal Parts thus, 34,1426; a good way, and very useful. Others draw a line under the Decimals thus, 34^{1426}, writing them in smaller Figures than the Integers. And others, though they use the Cöma in the work for the best way of distinguishing them, yet after the work is done, they use a Rectangular Line after the place of the Units, called *Separatrix*, a separating Line, because it separates the Decimal Parts from the Integers, thus $34\,|\,1426$. And sometimes the Cöma is inverted thus, 34'1426, contrary to the true Cöma, and set at top. I sometimes use the one, and sometimes the other, as cometh to hand."

CAJORI adds " The author generally uses the comma. This detailed statement from this seventeenth-century writer is remarkable for the omission of the point as a decimal separatrix."

The eighteenth century

99. My notes on the decimal calculus after 1700 will be even briefer : just a few glimpses.

The earliest American writer giving a full account of decimal fractions was ISAAC GREENWOOD (52), born in Boston 1702, graduated from Harvard College, then continued theological studies in London and began to preach, attended lectures by THEOPHILUS DESAGULIERS; appointed professor of mathematics at Harvard in 1727, and removed in 1738 because of continued dissipation; died in Charleston, S.C., 1745. He published in Boston 1729 his *Arithmetick, vulgar and decimal*, which was " the first textbook of its kind to be written in English by a native American " (SMITH), and contains the first American account of decimal fractions—account published one hundred and forty four years after STEVIN's *Thiende*. See figs. 47-48.

The Stevinian notation may still be observed in various eigh-

(52) F. CAJORI : The earliest arithmetic published in America (*Isis* 9, 391-401, 1927). This deals with PEDRO DE PAZ's *Arithmetica* (Mexico City, 1623), reference to GREENWOOD on p. 397. Needless to say there are no decimal fractions in PAZ's book. For ISAAC GREENWOOD see article by D. E. SMITH in *Dictionary of American biography* (vol. 7, 591, 1931).

teenth century works. For example, in the *Institutiones analyticae* of PAOLINO CHELUCCI (Rome, 1738) (53). CHELUCCI tried to improve STEVIN's notation in the same way as BEYER had done in 1603 (see § 97). That is, he writes $3.\overset{ii}{57}\overset{v}{}$ for 3.05007 : the maladroitness and danger of this simplification need not be pointed out. A somewhat better notation was used by HENRY SHERWIN in his *Mathematical tables* (3rd ed., London, 1741).

(4)2677 meaning .00002677

The redundant notations so frequent in the seventeenth century continued in the eighteenth. For example the abbé DEIDIER in his *Arithmétique des géomètres* (Paris, 1739), writes $32.6'3''4'''$ for 32.634.

The nineteenth century and after

100. Throughout the nineteenth and even the twentieth centuries the multiplicity of decimal notations continues but the decimal calculus is so well understood and the notations are so much alike that there is no real confusion. Decimals are indicated in a single way—by means of a decimal separator; the differences between notations concern the nature of that separator which is almost always a dot or a comma, and its level (e.g., 3.2 or 3·2 or $3^{\cdot}2$). Sometimes the decimal figures are printed in a different type or at a somewhat different level than the integers, but though this is pleonastic it is not really confusing. It is a curious fact that the world has not yet been able to reach an agreement on such a simple and abstract matter.

101. If the reader will now kindly take a general view of the evidence I have given—is it not quite clear that the publication of STEVIN's *Thiende* in 1585 was an astounding achievement? And does not the awkwardness of STEVIN's notation seem more forgivable when one considers the endless hesitations and redundancies of his followers for more than two centuries? For imperfect as his notation was it was superior to many ulterior ones and it had the excuse of trying to evidence the exponential

(53) I.e., PAOLINO DA S. GIUSEPPE delle Scuole pie, of Lucca (1682-1784). P. RICCARDI : *Biblioteca matematica italiana* (1,345-7, 1887). CAJORI (1928, 327).

idea at a time when that idea had not yet been vulgarized by the invention of logarithms.

As compared with the whole series of later textbooks the *Thiende* stands out with all the austere beauty and dignity of an Archimedian monument.

IV. — Decimal moneys, weights, and measures

102. But still we have not yet completed our examination of the *Thiende*, having left out for separate consideration the appendix which is the most remarkable part of it. I base my analysis on the French text which the reader himself may consult in our facsimile (pp. 149-60). The purpose of that appendix is to show how all human accounts and measurements can be considerably simplified if the decimal idea is applied to them. Stevin explains this in six articles devoted respectively to 1° land-measuring, 2° tapestry-measuring, 3° measurements of casks, 4° stereometry in general, 5° astronomical computations, 6° money masters, merchants, etc.

He proposes to give to each standard unit and to its decimal subdivisions the very names already given to the numbers and their decimals. Thus the unit of length or " verge " is called *commencement*, its tenth part, *prime*, the hundredth part, *seconde*, etc. Hence the result of a mensuration will be written and read exactly in the same way as the result of any other decimal computation. He explains this in article one and then in a more general way in the last article. The other articles contain redundant material, for example, in the fifth he makes a new plea for his " vulgar Germanic language which is the richest, the most ornate, and the most perfect of all languages " (facs. p. 157)—that was obviously very much on his mind,—but such defects are peccadillos as compared with the greatness of the fundamental idea.

Having understood the need of naming the submultiples of each unit it is curious that he did not think of naming their multiples. Nor did he realize the need of reducing all the units to a single one. For example, in article 1 he speaks of one unit of length, the *verge*, for surveying, and in article 2, of another the *aulne* (i.e., ell), for tapestries.

A remark of the last article affords an additional proof that STEVIN realized the exponential nature of the decimals and had guessed one of the rules of the exponential calculus. Says he (facs. p. 158): "It is clear that whichever be the nature of the unit, a *second* multiplied by a *third* will give a *quint* because two plus three equals five."

Then he gives two examples (facs. pp. 158-9) which illustrate the brevity and security of decimal computations as compared with the computations made with complex numbers. He ends with the remark that the accounts would be considerably easier if the actual coins, weights and measures were arranged on a decimal base—an advantage which our successors will probably appreciate—but that in the meanwhile we can arrange decimal computations even on the base of undecimal measures; it suffices to express the latter decimally (facs. 159-60), to complete our computations decimally and then to translate the final results in terms of the undecimal measures.

STEVIN used the decimal method in his geometry, and referred the reader of it to his *Disme*. See *Hypomnemata* (vol. 2, 1605, p. 4) or GIRARD's *Œuvres* (vol. 2, 341).

103. It is hardly necessary to point the need of some standard system of coins, weights and measures in STEVIN's days, for the units and their manner of combination and subdivision varied not only from country to country, but often from place to place and time to time, and the simplest commercial transaction might imply the passage from one system of measures and one system of moneys to another system of measures and another system of moneys. One may obtain some concrete idea of the resulting complications by examining a fifteenth or sixteenth century treatise on commercial arithmetic (54), or ancient books on metrology.

That need continued to be felt all over the world until the end of the eighteenth century, and it naturally became more and

(54) For example, see D. E. SMITH: The first great commercial arithmetic, Treviso 1478 (*Isis* 8, 41-9, 1926).

ALEXIS JEAN PIERRE PAUCTON: *Métrologie ou Traité des mesures, poids et monnoies des anciens peuples et des modernes* (972 p., Paris, 1780).

J. F. G. PALAISEAU: *Métrologie universelle ancienne et moderne, ou Rapport des poids et mesures des empires, royaumes, duchés et principautés des quatre parties du monde* (484 p., 1816, Bordeaux).

more acute as international commerce and industry increased. After the eighteenth century it was satisfied in some countries by the creation of the metric system. The diffusion of that system is not yet entirely completed and the need which worried STEVIN in 1585 has remained a crying need to this day in a large part of the world.

We may remark that until the time came when STEVIN's views were put into practice (two centuries later), the most consistent metrological system was the Sumerian (55). It is pleasant as well as startling to have to pay homage to the old Sumerians in a paper devoted to a sixteenth century mathematician !

Decimalization and standardization of weights and measures from 1585 to the middle of the eighteenth century

104. In spite of the fact that STEVIN's views were published in Flemish and French in 1585, and in English, in 1608—they do not seem to have attracted much attention. Of course we must realize at once the immense practical difficulties which were involved. Just remember how slow was the diffusion of the decimal calculus; yet how simple this was as compared with the introduction of decimal metrology, for the former could be accomplished without material changes while the latter could not be introduced without modifying the instruments of commerce and altering more or less deeply the economic and social fabric.

The great Flemish mathematician and physician ADRIAAN VAN ROOMEN (Louvain, 1561 — Mainz, 1615) published at Mainz 1609 a *Canon triangulorum sphaericorum* which he dedicated to ERNEST duke of Bavaria, archbishop and elector of Cologne, bishop of Liége and three other places (56). His preface to the duke includes the following statement (57) :

(55) THUREAU-DANGIN (1932, 37) : " C'est le seul ensemble de mesures qui, avant le système métrique, ait véritablement mérité le nom de système." However, the Sumerian system was not purely sexagesimal.

(56) For ERNST, Herzog von Baiern (1554-1612), see ENNEN in *Allgemeine deutsche Biographie* (vol. 6, 250-7, 1877). For ADRIANUS ROMANUS, see C. LE PAIGE : Notes pour servir à l'histoire des mathématiques dans l'ancien pays de Liége (*Bulletin de l'Institut archéologique liégeois*, vol. 21, 457-565, 1888; surtout p. 489-91). HENRI BOSMANS : *Biographie nationale de Belgique* (vol. 19, 848-89, 1907).

(57) ROMANUS' Canon is not available to me and I know the Latin preface

" Passerai-je sous silence cette invention divine par laquelle Votre Altesse a établi, entre les poids et mesures de tous genres, une harmonieuse liaison au point que, sous une seule dénomination civile, ou pour parler en arithméticien, dans une seule progression géométrique, tous les poids, toutes les longueurs, toutes les surfaces, tous les volumes trouvent leur mesure. Certes tant que les arts libéraux seront en honneur, tant qu'ils seront utiles, tant que le monde lui même subsistera, cette découverte excitera l'admiration des hommes."

How much of that is truth, and how much is undeserved flattery, giving credit to a powerful personage for the work of others? Allowance being made for the fulsome praise to the great which was a vice of that time, it is unlikely that ADRIAAN VAN ROOMEN would have said so much without foundation. On the other hand we know that duke ERNEST was deeply interested in science—chiefly astronomy and alchemy—and that the onerous duties of his five bishoprics left him time enough to patronize scholars and scientists such as JUSTUS LIPSIUS, LIEVIN VAN HULST (HULSIUS), TYCHO BRAHE, KEPLER, GERARD STEMPEL, ADRIAAN ZELST, GILLES GUILLON, ROMANUS himself. Hence it is quite possible that a man accustomed to divide his thoughts between practical and scientific matters should have hit independently upon the idea of unifying the weights and measures. For to make such an invention common sense joined with the continuous pressure of necessity was perhaps more precious then technical knowledge. What is stranger is that ADRIAAN VAN ROOMEN, who had been acquainted with STEVIN for a great many years and must have known his *Thiende*, did not mention him in this connection (58). What may have been the reason for his silence? Did he not wish to please STEVIN or was he afraid of displeasing the five-headed bishop? Whatever the case may be, it is worthwhile to record the existence of such a plan in or before the year 1609.

HENRY LYTE's booklet of 1619 on the *Art of tens* contains the following advertisement: " Those that would have either the Yard or two foote Ruler made very well according to the Arte of Tens which tables for that purpose I have set downe

to it only through LE PAIGE's French translation from which I quote (*ibidem*, 490).

(58) Of course STEVIN may be mentioned in another part of that work which I have not seen.

in this Booke let them repaire to Mr. TOMSON dwelling in Hosier Lane, who make Geometricall Instruments."

This shows that decimally graduated instruments were made and sold in London in 1619; it is I suppose the earliest instance of its kind.

In 1670, GABRIEL MOUTON (59) (d. 1694), vicar of St. Paul in Lyon, proposed a system of linear decimal measures which he connected with the size of the earth in order to give to it a universal base and authority. He was the first to think of such a physical connection independent of time and place, without which any standard would seem doomed to arbitrariness and impermanence. He called his measures geometric (60); their individual names being (in decreasing progression): milliare, centuria, decuria, virga, virgula, decima, centesima, millesima. The first three were the first terms coined to designate decimal multiples of the standard. This arrangement of decimal multiples and submultiples was badly spoiled by the existence of two middle terms virga and virgula (one virga equalling ten virgulas). The connection with the earth was made by giving to the milliare (or mille; in English, mile) the length of an arc of 1′ of a terrestrial great circle (61). Furthermore, MOUTON suggested connecting the standard of length with the length of the seconds pendulum.

The establishment of a decimal system of weights and measures implied two ideas: *a*) the decimal progression of all units; *b*) the selection of universal standards. STEVIN had explained the first idea but neglected the second; MOUTON was the first to explain both.

MOUTON was apparently the first to think of connecting his standard with the earth's size; but with regard to the second connection [with the pendulum] he had been anticipated and more than once. The use of the length of a pendulum of known vibration as a standard of length had already been discussed

(59) Observationes diametrorum solis et lunae apparentium etc. Una cum nova mensurarum geometricarum idea; novaque methodo eas communicandi et conservandi in posterum absque alteratione (Lyon 1670). (See fig. 49.) DELAMBRE: *Histoire de l'astronomie moderne* (2, 355-400, 1821). G. BIGOURDAN: *Le système métrique* (1901, 6).

(60) See KASPAR SCHOTT: *numeri geometrici* (1661, 1674).

(61) That is, MOUTON's milliare was theoretically equal to the nautical mile.

at a meeting of the Royal Society in December 1661 (62), then again, by CHRISTOPHER WREN at a meeting of February 15, 1662. The idea was clearly in the air.

On July 9, 1668 a clockmaker of Chartres, ESTIENNE, wrote to HUYGENS about it. Accepting for the seconds pendulum the length determined by JEAN PICARD (36 pouces 8 $\frac{1}{6}$ lignes) (62*bis*) he proposed to call that length the " Hugenian ell." HUYGENS accepted the principle but rejected the name on the ground that it was not ESTIENNE's business to select it but rather that of the Royal Society fellows to whom the idea had occurred many years previously (63). In his *Mesure de la terre* (Paris, 1671) PICARD recommended very warmly the pendulum standard though he already suspected that it might vary with the latitude. The Académie des sciences decided in that year (1671) to send two astronomers, JEAN RICHER and MEURISSE to Cayenne (lat. 4°56′ N) to make various observations under equatorial conditions. They stayed in Cayenne from April 1672 to the end of May 1673, and RICHER proved by experiments extending over ten months that the seconds pendulum was shorter in Cayenne than in Paris (64). RICHER's results must have been known in the Académie circle soon after his return, and they were published by him in 1679 (64.1). However, they were contradicted by others obtained in Uraniborg, London and The Hague, and the matter remained doubtful. The great HUYGENS, who had followed the subject closely from the beginning, was still hesitating as late as 1687.

(62) Letter of R. MORAY to HUYGENS, dated Whitehall, Dec. 13, 1661, in *Œuvres de* HUYGENS, Lettre Nr. 935 (vol. 3, 425-8).

(62bis) According to M. GLIOZZI (1932, 32-35) the earliest attempts to determine the length of the seconds pendulum were made by GIOVAN BATTISTA RICCIOLI in 1642, and by MARIN MERSENNE in 1644. RICCIOLI's account is included in his *Almagestum novum* (Bologna 1651, vol. 1, 86); MERSENNE's account in his *Ballistica* (Paris 1644, p. 44).

(63) *Œuvres de* HUYGENS (vol. 6, 232-4, 258-61). More letters on the subject may be found in that very precious collection, by index sub voce " mesure universelle."

(64) In Paris 3 pieds 8 1/2 lignes; in Cayenne 1 1/4 ligne less (*Mémoires de l'Acad.*, I, 177); that is, less than 3 per thousand shorter.

(64.1) JEAN RICHER : *Observations astronomiques et physiques faites en l'isle de Caïenne* (Paris 1679). I have not seen the 1679 edition, but only the reprint (or memoir bearing the same title) in the *Mémoires de l'Académie royale des sciences* (tome 7, 233-326, 320, Paris 1729). See also (*ibidem*, tome 1, 158, 177, Paris 1733). RICHER himself had no doubts as to the correctness of his observations.

He seems to have finally changed his mind and admitted the variability of the pendulum with the latitude at some time between May 1, 1687 and April 24, 1688 (64.2). Note the slowness of that evolution : HUYGENS and others kept pondering on the subject for more than fifteen years before reaching a conclusion. This was due to the fact that the effect to be observed was very small. But as soon as it was realized that the seconds pendulum was not invariable it lost its value as a universal standard of length.

104*bis*. This section dealing with T. L. BURATTINI (c. 1615-c. 1682) was interpolated after reading MARIO GLIOZZI's paper of October 1932 of which I only heard a year later. GLIOZZI's information is derived from the writings of ANTONIO FAVARO to which I duly referred : Intorno alla vita e alle opere di T. L. BURATTINI (*Memorie del R. Istituto Veneto*, vol. 25, no. 8, 140 p., folio, Venice, 1896) very elaborate study; T. L. BURATTINI (*Atti d. R. Ist. Veneto*, vol. 54, 110-6, 1896) ; Supplemento (*Ibidem*, vol. 59, parte 2, 855-60, 1900).

TITO LIVIO BURATTINI was born c. 1615 in Agordo (Belluno). In 1637, he went to Egypt, where he resided four years studying Egyptian antiquities; in 1641, he moved to Germany, then to Poland where the rest of his life was largely spent. Orientalist, soldier, mechanician, statesman, courtier, financier, maker of excellent lenses for telescopes and microscopes, astronomer, —he was a remarkable example of a seventeenth century scientist and adventurer. He died c. 1682.

Our interest in him is due to a little book entitled *Misura universale* which was published by the Franciscans in Vilna 1675 (see fig. 50). It is now exceedingly rare : there are copies in the Biblioteca nazionale of Rome, in the Academy of sciences of Cracow, and in Leningrad. A new edition prepared by the late LUDWIK BIRKENMAJER was published under the auspices of the Cracow Academy in 1897 (64.3). I know the *Misura*

(64.2) HUYGENS : *Œuvres* (vol. 7, 117; vol. 9, 130, 162, 272).

(64.3) Misura universale di T. L. BURATTINI. Podlug wydania wilenskiego z Roku 1675 wydal powtórnie wydzial mat. przyr. Akademii umiejetnosci w Krakowie (v + 32 p., 4 pl., Krakowie, 1897). Reprint of the Italian text with Polish introduction. A Polish translation of the Italian text by SOFIA KARLINSKI BIRKENMAJER was published by the same academy in the same year : T. L. Burattiniego Miara powszechna.

universale only through that reprint and FAVARO's summary of 1896.

In that treatise BURATTINI, who had been pondering on the subject at least since 1645 proposed to take as universal standard of weights and measures the length of the seconds pendulum, and he called it *Metro Cattolico* or *metro* (= meter) this being the earliest use of that word for a standard of length. He also suggested deriving from that standard, a standard of weight, the *Peso Universale:* the weight of the water contained in a cube the side of which equals one sixteenth of the metre. BURATTINI thought his ideas were new, and considering the fact he was residing in Poland, that illusion was pardonable.

His work deserves to be mentioned because it shows that the idea was in the air, but its historical importance is otherwise small, for it is at one and the same time posterior and inferior to MOUTON's treatise of 1670.

Indeed BURATTINI had only grasped one of the two fundamental ideas: he had seen the need of a standard connected with a physical constant which would insure its universality,—but he had not grasped the decimal idea so well explained by STEVIN ninety years earlier. His meter was divided into sixteen parts, then each part into sixteen smaller ones, then each of the smaller parts into sixteen others: thus the main subdivisions were 1/16, 1/256, 1/4096. He had not realized, as MOUTON had, the expediency of giving names to the multiples and the submultiples of the standard. Neither did he suspect that the length of the seconds pendulum was not invariable, but we can hardly blame him for this considering that HUYGENS had dogmatically stated its invariability in his *Horologium oscillatorium* (Paris, 1673, 36) and did not finally abandon his belief until fifteen years later.

104*ter*. JACQUES CASSINI in his *Traité de la grandeur et de la figure de la terre* (Paris, 1720) suggested the determination of a standard foot equal to one hundredth of an arc of 1″ of the meridian; on that basis the toise (or six feet, fathom) would have been contained a thousand times in the arc of 1′, and the degree would have been equal exactly to 60.000 toises. However, it was already clear that the exact determination of the length of the meridian implied many difficulties and might open the door to disagreements.

In 1748, LA CONDAMINE (64[4]) concluded that it would be preferable to take as standard the length of the seconds pendulum at the equator.

Genesis of the metric system

105. So much for purely scientific efforts but metrological reforms could not be accomplished except by political authorities. The endless diversity of weights and measures was a great obstacle to the development of commerce, and some clear sighted administrators tried to suppress it within the boundaries of their own countries. The account of their endeavours is an important chapter of economic history, but it does not concern us except indirectly. A few indications will suffice.

PHILIBERT ORRY, general financial controller of France until 1745, planned to unify French measures and was thinking of adopting as standard toise twice the length of the equatorial seconds pendulum. He was assisted by that great scientific administrator, CHARLES DUFAY, whose untimely death in 1739 stopped the project.

Relatively few people are aware that similar efforts were made in England about the middle of the eighteenth century, witness two Reports of the House of Commons dated 1758 and 1759 (65). These reports dealt only with the unification of standards, not with the selection of natural standards nor with their rationalization. However, the question was again brought up in the House in 1789 by Sir JOHN RIGGS MILLER and after having been in touch with TALLEYRAND he addressed the House a second time on Feb. 5, 1790 insisting on the necessity of selecting a natural and permanent standard (such as the London seconds pendulum) and of dividing it decimally.

For JEFFERSON's efforts towards the decimalization of United States coinage, weights and measures (1790), see Miss HELLMAN's memoir (1931). JEFFERSON had a very clear grasp of the matter. The earliest American book on decimal metrology outside of

(64[4]) Nouveau projet d'une mesure invariable propre à servir de mesure commune à toutes les Nations (*Histoire de l'Académie pour* 1747, Histoire p. 82-88, Mémoires, p. 489-514, Paris, 1752). Presented to the Académie in Nov. 1747, read at a public meeting, April 24, 1748.

(65) HELLMAN (1931, 281-4).

JEFFERSON's own Report (New York, 1790) was *The American accomptant* by CHAUNCEY LEE (Troy, N.Y., 1797) (66).

Creation of the metric system

106. Let us now return to France, where the decimal reform was finally accomplished. Attempts were made to unify the weights and measures by royal declaration in 1766, and again under LOUIS XVI by his two great ministers, TURGOT and NECKER; meanwhile the provinces were becoming more and more conscious of the need of unification and in 1789 the " cahiers " of many bailiwicks included resolutions *ad hoc*.

These revendications were very ably summarized in March 1790 in the *Proposition faite à l'Assemblée nationale sur les poids et mesures*, by the famous TALLEYRAND, bishop of Autun. TALLEYRAND suggested the selection of the length of the seconds pendulum at latitude 45° for the standard of length, and recommended concerted action with England : the new measures might be established by a committee selected, one half by the Académie des sciences and one half by the Royal Society. It is a great pity that this could not be accomplished; the outbreak of the French Revolution made further coöperation between the two countries impossible; on the other hand, we must bear in mind that without the Revolution so radical a change in the weights and measures might have been indefinitely postponed, —as it was indeed in other countries.

TALLEYRAND's conclusions were generally approved by the Assemblée nationale on May 8, 1790, except that it did not specify which seconds pendulum should be selected as standard, presumably in order to make coöperation with England easier; nor was any mention made of decimalization.

A commission of the Académie reported on October 27, 1790, that the new system of coins, weights and measures should be decimal, and that its success would largely depend on the decimalization. Another commission reported on March 19, 1791 on the choice of the universal standard : it rejected the seconds pendulum on the incontrovertible ground that the fundamental

(66) HELLMANN (1931, *Isis* 16, 304, figs. 1-4).

unit of length should not be dependent on an arbitrary unit of time; it chose the length of the quarter of a meridian, deciding that the ordinary unit would be equal to the ten millionth part of that length; it explained practical means of realizing its program (67). The new system was finally established by the law of 18 germinal an III (7 April, 1795) (68). On 21 prairial an VI (9 June, 1798) TALLEYRAND invited friendly and neutral nations to send delegates to an international conference for the final determination of weights and measures. On 4 messidor an VII (22 June, 1799) prototypes in platinum of the standard meter and kilogram were deposited at the French archives by a scientific commission headed by LAPLACE.

An international scientific commission called *Conférence internationale du mètre* met in Paris 1872, thirty nations being represented, the main purpose being to improve the determination of the meter and the kilogram, prepare new international prototypes and insure their permanence.

An international committee of weights and measures, and an international bureau of standards *(Bureau international des poids et mesures)* were established by a diplomatic conference of twenty nations in Paris, May 20, 1875.

The first general congress of weights and measures met in Paris, September 1889. On that occasion the new prototypes of meter, kilogram, and centigrade thermometer were sanctioned, and national prototypes distributed. The unit of length was redefined as the length of the international prototype meter at the temperature of melting ice. The relationship with the meridian had to be abandoned because the original ratio was found to be slightly inaccurate, and because a standard of length dependent upon the progress of geodetic measurements would lose ipso facto the essential quality of permanence. The meter has not become arbitrary on that account: indeed the international prototype was originally related to the meridian, and one may

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(67) These two reports may be found in the *Histoire de l'Académie royale des sciences, année* 1788 (sic). (Paris, 1791, p. 1-16). The members of the first commission were BORDA, LAGRANGE, LAVOISIER, MATHIEU TILLET, CONDORCET; those of the second, BORDA, LAGRANGE, LAPLACE, MONGE, CONDORCET.

(68) BIGOURDAN (1901, 65-70).

still say that it is approximately equal to the forty millionth part of it (69).

107. The history of the gradual establishment of the metric system in France and of its diffusion among the rest of the world is a long story involving all kinds of administrative, legal and diplomatic formalities which do not concern the scientist. On the other hand, one could not give a full account of the determination, preservation, comparison, and reproduction of the standards without touching upon a large number of physical and chemical problems, without making so-to-say a cross section of the history of physics in the nineteenth century.

Our purpose was simply to show the development of STEVIN's thought of 1585. If we take 1795 as the birth year of the metrical system—two centuries had already elapsed by that time since STEVIN's first proclamation of the decimal idea. Another century was still needed to perfect the organization of that system (1899). And how long will it take to make it not simply international, but as general as our system of numbers?

V. — DECIMAL DIVISION OF ANGLES AND TIME

108. At the present time the decimal system may be said to be the only system used for scientific purposes all over the world, with the exception of time and angle measurements. I shall not discuss the division of the week into seven days nor the division of the day into hours, both of which especially the latter are very ancient relics. The French Revolution tried to introduce a decimal week *(décade)* but failed (70).

On the probable analogy of an ideal year of twelve thirty-day months, the early Sumerians had divided the day into twelve equal *danna* of thirty *gesh* each. Later that division into 360 parts was applied to parallels, and later still (in Achaemenian times, c. 558-330) to the ecliptic (zodiac, dodecatemories) (70[b18]).

(69) According to the latest geodetic measurements the ten millionth part of the quarter of the meridian exceeds the meter by two tenths of a millimeter : a difference ($\frac{2}{10000}$) which cannot be appreciated except with very precise instruments. Hence when we speak of the meter in a general way, without reference to very precise measurements, its former definition is still correct.

(70) The Republican calendar of which this was a feature lasted only from October 5, 1793, to Jan. 1, 1806.

(70[bfs]) The earliest Greek work in which that division of the ecliptic occurs is one as cribed to HYPSICLES (ii-i B. C.)

All this however was independent of the sexagesimal system—another Sumerian invention to which we have already referred. We have seen that Babylonian astronomers used sexagesimal "*fractions*" and transmitted them to the Greeks—who failed to understand what was best in them. These fractions invaded western Europe and their equivocal usage was almost universal until the seventeenth century when decimal fractions began to displace them. We have told the story of that very slow displacement.

The sexagesimal division of our hours into minutes and seconds is a relatively late development. It is very different of course from the Sumerian division of the day into 360 parts. It was not used by PTOLEMY, but by his commentator THEON OF ALEXANDRIA (second half of fourth century) (71); Arabic astronomers transmitted it to the western world.

109. The displacement of sexagesimals has remained incomplete to this very day, and we still divide hours and degrees in that manner. That tradition is so deeply rooted that few people have ever ventured to shake it. The earliest example I know of such boldness is in a Latin composite Ms. (72) written between 1445 and 1450 by one THEODERICUS RUFFI, friar minor in Gronenberch, and containing a number of mathematical, astronomical and medical treatises by various authors. In one of those treatises called *Instrumentum de distantiis civitatum et regnorum et dicitur cosmographia* (fol. 174 r°-176 r°), one may read :

" Et notandum quod in praesenti tabula quilibet gradus et hora dividitur in 100 minuta, et quodlibet minutum in 100 secunda et sic de aliis." (73)

This text remained unpublished and hence its influence was very restricted. In fact, there is no appearance that anybody paid any attention to the centesimal division of the degree and

(71) THUREAU-DANGIN (1932, 76).

(72) Cod. lat. 11067, Munich, State Library.

(73) SIEGMUND GÜNTHER : Analyse einiger kosmographischer Codices der Münchener Hof- und Staatsbibliothek (*Studien zur Geschichte der mathematischen und physikalischen Geographie*, Halle a. S., 1879; 215-75, 1878, cf. p. 249). M. CURTZE : PETRI PHILOMENI *de Dacia in algorismum vulgarem* JOHANNIS DE SACROBOSCO (Copenhagen 1897, p. viii). CANTOR (2^2, 1900, 185). TROPFKE (1^3, 58, 1930) says wrongly that the quadrant is divided into 100 parts : nothing of the kind. D. B. DURAND : The origins of German cartography in the XVth cent. (Harvard doct. thesis; to be published).

of the hour just mentioned. Nor do we find any similar suggestion until STEVIN's independent one in 1585.

110. In article V of the appendix to the *Disme* (facs. 156-7) STEVIN says: " We call the 360 degrees also *commencements*, and write them so: 360(0), and each degree 1(0) will be divided into 10 equal parts, each of which called 1(1), and each 1(1) will be divided into 10(2), etc." The decimal division of the degree is here proposed in the clearest manner, and connected by STEVIN's simple genius with all other measurements.

111. In the logarithmic tables compiled by HENRY BRIGGS (d. 1630) but only published after his death by HENRY GELLIBRAND: *Trigonometria Britannica* (Gouda, 1633), the degrees are divided not into sixty minutes but into a hundred centesimae. These tables give the logarithms of trigonometrical lines with 14 decimals for every centesima.

LAGRANGE became interested in the decimalization of angle measurements, and during his Berlin residence he persuaded one of his younger colleagues of the Prussian Academy, JOHANN CARL SCHULZE, to compile logarithmic tables for centesimal division of the degree; but only the preface of these tables was ever published (Berlin, 1778) (74). It would seem that SCHULZE completed the tables and that these were ready for publication when LAGRANGE changed his mind and realized it was better to divide the quadrant decimally instead of the degree. Faithful SCHULZE agreed and enlisted the cooperation of GEORGE GOTTLIEB SCHMIDT to recompile the tables on the new base. Only a part of the new tables was published in BODE's *Astronomisches Jahrbuch für* 1798 (Berlin, 1795): " Etwas über die Decimaleintheilung des Quadranten."

112. We have seen that LAGRANGE was a member of the commissions appointed by the Académie des sciences to study the rationalization of weights and measures. Hence we are not surprized that their report of March 19, 1791 considered the rejection of the degrees, minutes and seconds almost as a matter

(74) After MASCART (1919, 580-94). I tried to find evidence of LAGRANGE's interest in his *Œuvres* but failed. Apparently he did not write on the subject. In a letter to d'ALEMBERT dated Berlin, Jan. 27, 1778, he refers to SCHULZE (1749-90), who had just been appointed by the Prussian academy, but no mention is made of decimal tables (*Œuvres de* LAGRANGE, vol. 13. 335, 1882).

of course, and replaced it by a decimal division of the quadrant, without however entering into any details as to the application of their principle. It should be recalled that in their opinion the *quarter* of the meridian was the real unit of length, from which the meter was to be derived : (75) they found it unreasonable to divide the quarter of the meridian in one way and the quarter of a circle in another.

The ideas of the Académie were carried into practice by a man to whom the technical elaboration of the decimal system is deeply indebted, the chevalier JEAN-CHARLES DE BORDA (Dax, 1733-1799). He undertook to compile trigonometrical tables with seven decimals for the centesimal division of the quadrant, and his manuscript was apparently ready by 1793 : these being the earliest tables of their kind. At the same time BORDA supervised the construction of instruments bearing the same graduation. The publication of his tables was delayed by various accidents.

In the meanwhile JEAN FRANCOIS CALLET (1744-98) used them to compile his own *Tables portatives de logarithmes*, which contained logarithms of numbers and of trigonometrical lines for both the sexagesimal and decimal division, the latter up to the fourth decimal (76). These tables were published by FIRMIN DIDOT

(75) " Le quart du méridien terrestre deviendroit donc l'unité réelle de mesure, & la dix millionième partie de cette longueur en seroit l'unité usuelle. On voit ici que nous renonçons à la division ordinaire du quart du méridien en degrés, du degré en minutes, de la minute en secondes; mais on ne pourroit conserver cette ancienne division, sans nuire à l'unité du système de mesure, puisque la division décimale qui répond à l'échelle arithmétique, doit être préférée pour les mesures d'usage; & qu'ainsi l'on auroit pour celles de longueur seules deux systèmes de division, dont l'une s'adapteroit aux grandes mesures, & l'autre aux petites. La lieue, par exemple, ne pourroit être à la fois & une division simple du degré, & un multiple de la toise en nombres ronds. Les inconvéniens de ce double système seroient éternels : au contraire ceux du changement seront passagers; ils ne tomberont d'ailleurs que sur un petit nombre d'hommes accoutumés au calcul, & nous n'avons pas cru que la perfection de l'opération dût être sacrifiée à un intérêt, qu'à beaucoup d'égards nous pouvions regarder comme personnel." (*Histoire de l'Académie pour* 1788, p. 10, Paris 1791).

(76) " De minute en minute ou de dix-millième en dix-millième pour les 100 degrés du quart de cercle suivant la nouvelle division." The name " degré " was still given to the centesimal part of the quadrant as well as to sexagesimal; the centesimal degree was divided into 100 minutes, the minute into 100 seconds. But it is not necessary to speak of minutes or seconds, as all the decimals hold together and one may take as many of them as one pleases : for ex. two and call

in Paris 1795 (an 3) and stereotyped. They were the first of their kind to appear in print (77).

More elaborate centesimal tables were prepared at the end of the century by order of the French government; these are the so-called *Tables du cadastre* which were computed from 1794 to 1799 under the direction of G. RICHE DE PRONY and remained in manuscript. These tables were computed up to the 14th decimal. A reduction of them to the 8th decimal was published by the *Service géographique de l'armée* in 1891.

BORDA's tables were edited posthumously by J. B. J. DELAMBRE; *Tables trigonométriques décimales* (Paris, 1801, an 9).

113. H. ANDOYER published in 1911 new fundamental tables *Nouvelles tables trigonométriques fondamentales* (Paris, 1911) which are primarily sexagesimal tables, but contain logarithms for every centesimal with 17 decimals.

Many efforts have been made, and are still being made, in France to promote the decimal division of the quadrant. The leader of that movement in recent times was EMILE GUYOU (1843-1915), sailor and mathematician (78), who was warmly supported by HENRI POINCARÉ. In 1899 GUYOU, being then Capitaine de frégate, issued in vol. 6 of the *Annales du Bureau des Longitudes* (of which he was a member) a memoir entitled *De l'extension du système décimal à la mesure de la circonférence. Éphémérides et tables numériques en parties décimales du quart de cercle préparées pour une application à la navigation* (90 p.). This was part of a practical experiment: these ephemerides were distributed to a number of sea captains, together with a decimal chronometer, a decimal compass, a decimal sextant, a decimal protractor, and decimal charts. I do not know the results of those experiments, but hardly expect them to have been favorable to the decimal idea, sailors being notoriously conservative (79).

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them minutes, or four and call them seconds; or call the first two, minutes and the two others, seconds, or take only three. This illustrates the superiority of the decimal notation.

(77) CALLET's book contains also tables for the conversion of sexagesimal degrees, minutes and seconds into centesimal ones, and vice versa.

(78) See notice and portrait in *Larousse mensuel* (vol. 3, 732, 1916).

(79) Witness their strange opposition to the use of chronometers (*Isis* 6, 128).

114. Few countries to-day avail themselves of the decimal division of the quadrant, these countries being France and others, such as Belgium, which are strongly under French influence, and even in these countries the use is relatively small. The simultaneous employment of two kinds of degrees would be confusing but for the fact that the French have two different names for them

90 degrés = 100 grades

(Both words derive from the same Latin word gradus, degré being the popular derivation, grade a learned doublet. I do not know when the term grade was introduced and by whom.)

An additional advantage of the decimal division of the quadrant is that as 100 grades are approximately equal to 10.000.000 meters, one grade is approximately equal to a hundred kilometers and one minute of a grade—or more correctly a centigrade— (80) is approximately equal to one kilometer—relations which are very easy to remember. It is true one minute (of a degree) equals one nautical mile, but the nautical mile is different from the English statute mile, and the ratios of either kind of mile to smaller units of length (whether foot or meter) are very complicated.

The prospects of the diffusion of the decimal division of the quadrant are not brilliant to day, and more's the pity, for our present system is disgraceful. People do not realize how complex it is, the word " sexagesimal " often applied to it being a very incomplete description of it. In fact, our system implies three ratios : nonagesimal division of the quadrant, sexagesimal division of the degree and the minute, decimal division of the second (or sometimes of the minute); and to this must still be added the sexagesimal division of the hour and minute of time, and the decimal division of the second of time (or of the minute).

Shades of the unknown author of the *Instrumentum de distantiis civitatum* (c. 1447) ! Shades of STEVIN and of LAGRANGE !

(80) Indeed the correct names of the decimal subdivisions of the grade are decigrade, centigrade, milligrade; the terms minutes and seconds having then only sexagesimal meanings.

VI. — The decimal idea

115. To return to the decimal system in general there is a strange contrast on the one hand between its snail-like progress and the continued unintelligence of men and on the other hand the fact that the fundamental idea was apprehended a very long time ago.

Not to speak of the vague conceptions of number scales which were already implied in the early Egyptian and Sumerian systems of numeration (81), and of other similar implications, we find in the *Liber algorismi de practica arismetrice* translated from an unknown Arabic original by John of Seville (first half of twelfth century) (82) some recognition of the fact that sexagesimal fractions are but a special case of something more general : their importance lies in the system, not in the number sixty. This is expressed even more clearly in the *Demonstratio de minutiis* by Jordanus Nemorarius (first half of thirteenth century) (83), wherein a general system of fractions *(partes consimilis sumptionis)* is considered, the denominators of which are connected by the ratio e^x (the author had in mind especially sexagesimal fractions, but does not speak of the ratio 60, only of the general ratio e).

116. However, these authors being familiar with only one such scale of fractions—the sexagesimal—did not realize the new advantages which would accrue if the base of the fractions was the same as that of the numbers. The first to see that and to see it well was Simon Stevin in 1585. He expressed it clearly if indirectly by stating that the main advantage of his decimal calculus was the avoidance of " nombres rompuz " (ordinary fractions) —the possibility of completing one's accounts as if all numbers were integers (see facsimile 136, 139, 159).

117. Stevin was not unaware of the theoretical advantages of another scale, namely the sexagesimal which was extensively

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(81) In spite of the impurity of their sexagesimal system, the Sumerian anticipation was remarkably good in that the sexagesimal base was extended to submultiples as well as to multiples.

(82) My *Introduction* (2, 169).

(83) Text quoted by G. Enestrom (*Bibliotheca mathematica*, vol. 14, 172, 1914). Tropfke (1^3, 172, 1930).

used in his time, as it still is in ours, for astronomical purposes. He pointed out (facs. 156) that the number sixty has many factors 1, 2, 3, 4, 5, 6, 12, 15, 20, 30 (84); yet he added that in spite of that the ratio sixty cannot be as convenient as the natural ratio ten. He did not express himself very clearly on this point—not even in the original Flemish text,—and missed a great opportunity. What he ought to have said—and what was implicitly in his mind—is that the practical superiority of the base 10 in spite of every advantage which other numbers may possess—lies simply in its being the very base of our number system.

The French academicians pointed out in their first report on weights and measures (27 oct. 1790) (85) the potential superiority of the duodecimal scale, but added regretfully that its adoption was unthinkable because our immemorial and complete devotion to the decimal system of numbers.

Many of our contemporaries in spite of the immense treasures of knowledge and experience which have been opened to them within the last century—are far less intelligent in this respect than the academicians of 1790, or even STEVIN,—for their stock objection to the decimal system is the theoretical advantage of other bases such as 8, 12, 16, or 60.

These advantages are clear enough. One great defect of the number 10 is that it can be halved only once while 12 can be halved twice, 8, thrice, and 16, four times: now this halving process is very congenial to the human mind, witness for instance the use of quotations 1/2, 1/4, 1/8 on the stock exchange. All of which is true enough but these contemporaries of ours fail to understand—what STEVIN did understand—that the advantages of other bases would be worse than worthless unless these numbers were chosen as the base not only of our fractions but of our number system as well.

Now is such a change conceivable? We cannot but repeat with the report of 1790 that it is not. Mankind is absolutely committed to the decimal base of numbers. There have been other bases to be sure in the distant past and in remote countries,

(84) In this he was but repeating (whether he realized it or not) what THEON OF ALEXANDRIA had remarked twelve centuries earlier (THUREAU-DANGIN, 1932, 6).

(85) *Histoire de l'Académie royale, année* 1788 (p. 6).

but the decimal base became very early almost the only one among all civilized peoples (86). In fact this is one of the very few things upon which mankind is united. Almost all the numbers of all the books which are published to-day in many hundreds of different languages all over the earth—almost all these numbers are decimal. This unanimity is the more impressive because it was spontaneous. Happily it was never found necessary to organize international congresses or committees in order to select a number base; for if that necessity had arisen, it is probable that divergencies would have occurred, and those divergencies would have easily grown into schisms.

Indeed there is much to be said for the other systems. A sexagesimal system would be splendid except for the school children who would have to learn their table of multiplication up to 60×60, and memorize fifty-nine different numerals plus the zero. A duodecimal base would perhaps be the best on many grounds, and it would only require two additional numerals. However, all those discussions are singularly futile, because we are irrevocably bound to the base ten, which has become as much a part of our psychology, as our ten fingers and our ten toes are an integral part of our anatomy.

I hope mathematicians will forgive me for insisting on the obvious, but my experience with people of many kinds has proved to me the necessity of doing so in this case. Let me still say this : suppose that a human group was strong enough to establish another number system and to diffuse it sufficiently to compete with the decimal. Just imagine the confusion which would thus be created !

By way of illustration I give in the following table the transcription of five numbers in four different systems (of bases 8, 10, 12, 60). The letters *a* and *b* which occur in the third column represent the tenth and eleventh numerals of the duodecimal system. The numbers of the second column are those with which we are familiar; the numbers of each horizontal line are equal, that is, they represent in different ways the same quantity of units.

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(86) For a survey of the archaeological aspects of this question see map 13, Distribution of number systems in Father WILHELM SCHMIDT : *Die Sprachfamilien und Sprachenkreise der Erde. Atlas* (Heidelberg 1926).

$B_{(8)}$	$B_{(10)}$	$B_{(12)}$	$B_{(60)}$
103	67	57	17
25257	10927	63a7	327
745505	248645	bba85	1945
100	64	54	14
7020	3600	2100	100

In other words, if men used more than one system of numbers, one could never be sure of the meaning of any number unless its base were explicitly stated or implicitly known. And can one conceive of any advantage of a new number system which would compensate us for the chaos which its introduction would thus bring into being?

We are bound to the decimal system of numbers and by the same token—as STEVIN perceived three and a half centuries ago—we are bound to a decimal system of measures.

VII. — THE ANGLO-AMERICAN WEIGHTS AND MEASURES

118. By contrast with the Stevinian system, let us now consider the systems in use in the English speaking world.

Let us first examine the English coinage, because in this case we can enlist American support. Indeed, every American is so convinced of the superiority of the American system over the English that he hardly thinks it worth while to discuss the matter. What is more, if an incredulous Englishman should ask him to justify his conviction, he will generally be able to do so correctly. The American currency (he would say) is easier to deal with than the English because the accounts involving no complex numbers, can be made without fractions. The ratios between different items being decimal are taken care of by a simple shifting of the decimal point. On the other hand, if we consider the following items of the English currency: guineas, pounds, crowns, florins, shillings, pence, and farthings,—there are no less than 17 connecting ratios between them, namely

1.05; 2; 2.5; 4; 4.2; 10; 10.5; 12; 20; 21; 24; 48; 60; 240; 252; 960; and 1,008 (87).

After having witnessed the American's triumph on the matter of coinage, it is very amusing to tackle him on the matter of weights and measures—which is really the same, but unless he be scientifically trained and scientifically minded (two different things) the chances are that his attitude with regard to weights and measures will be diametrically opposed to his earlier ones. The arguments which seemed to him incontrovertible with regard to coins, become specious with regard to every other measure! He will now speak of the superiority of the base 12 or 16, forgetting on the one hand that the base of his numbers is neither 12 or 16, but 10 and will never be anything else, and on the other hand that the system of measures he is so fond of is not built on a single base but on many.

Consider the measurement of length. If one confine's oneself to four items: mile, yard, foot and inch, there are already six connecting ratios: 3; 12; 36; 1,760; 5,280; 63,360.

The units of area: square inch, square foot, square yard, square rod, rood, acre, square mile and township involve 45 connecting ratios some of which are very complicated.

Says Professor KENNELLY (1905, 322-24):

"The same comparison and contrast apply to volumes in the two systems. We have the cubic inch, cubic foot, cubic yard and cubic mile. International metric measure has the cubic meter and decimal derivatives. That is to say, there is virtually but one unit.

For the dry measure of volumes, we have, to make our confusion complete, pints, quarts, pecks, bushels, barrels, quarters and chaldrons. Moreover, our bushels, although nominally the same, actually vary according to the commodity measured; there being, according to 'The World Almanac,' some 20 different sorts of bushels by the laws of the United States, from a bushel of bran weighing 20 pounds avoirdupois, to a bushel of fine salt weighing 167. Add to this joy the recollection that there is a difference of about 8 per cent. between the British and American bushels, pecks, quarts, etc., and we attain the happy result that none can say precisely what quantity is meant by the term 'bushel' save by chance or context.

In regard to units of weight, or, more strictly, of mass, the metric system has the gram, which may be defined as the weight of a cubic centimeter of distilled water under specified conditions. Or, expressing the same relation in other words, a cubic meter of water weighs a metric ton of 1,000 kilograms and a cubic decimeter (called a liter) weighs one kilogram. Heavy weights are expressed in metric tons, lesser weights in kilograms, small

(87) These and other ratios quoted below are taken from KENNELLY (1905).

weights in grams and tiny weights in milligrams. A mosquito will weigh in the neighborhood of a milligram, a U.S. nickel, fresh from the mint, five grams, an average man seventy kilograms, an average elephant about 3,000 kilograms or 3 metric tons. In this manner the weight of any object is brought immediately before the mind in relation to that of any other object, large or small, since virtually one and the same unit—the gram—is used throughout.

In contrast with this simple expression of weights in the metric system, we have in our systems three kinds of weights : viz., apothecary's weight, troy weight and avoirdupois. The two first mentioned have their ounces in common but differ otherwise. Although most substances are sold by avoirdupois weight, the precious metals sell by troy weight, and drugs in prescriptions usually sell by apothecary's weight. The ounce and pound weights kept by the druggists are for this reason generally different from the ounce and pound weights kept in the other stores. It is impossible, therefore, to determine, except by context, precisely what is meant by the word ' pound ' as a unit of weight in English-speaking countries. It may be the troy pound of 5,760 grains, or the avoirdupois pound of 7,000 grains...

The cross-ratios connecting these various units are several hundred in number and very complex. Since, however, the ordinary citizen only deals with avoirdupois weight, in which there are nine units, the cross-ratios are 45 in number. Moreover, there are two tons in this country, a long ton of 2,240 pounds and a short ton of 2,000. In general literature, it is frequently impossible to determine which of these tons is referred to.

When liquid measure is considered, the medley and jumble of British measures is, if possible, worse. The British gallon is defined as 10 pounds avoirdupois of water at 62° F., the volume being 277.274 cubic inches. In the United States, the gallon is fortunate enough to contain 8.3389 pounds avoirdupois, or 58,372 grains, of water at a temperature of 39°.83 Fahrenheit. The U.S. gallon is thus about one sixth smaller than the British. The same happy ratio affects all the subdivisions of each system, viz., pints, quarts, etc. It is often difficult to tell whether English gallons or U.S. gallons are referred to, when the term is encountered in literature. Occasionally an American book will quote British gallons, or vice versa, without any reference to the discrepancy. Moreover, we have apothecary's fluid measure containing as units the minim, drachm, ounce and pint. These measures are again different in Great Britain and in the United States.

If we should attempt to collate all the British and American units of volume, both ' dry ' and ' fluid ', and express each unit of the table in terms of all the others, the table would contain more than a thousand entries or crossratios. In the corresponding table of the metric system there would be virtually only one unit, and all others would be expressed therein by a shift of the decimal point.

If an attempt were made deliberately to construct a medley of weights and measures as a burlesque, for sensible practical people to make sport of, it may be questioned whether such a farcical hypothetical medley would be more illogical, incoherent or cumbersome than our own...

So complex is our customary system of weights and measures, that there are comparatively few persons who can recite from memory all the various tables taught in our schools. So ambiguous is the system, that many cultured persons are not aware of the difference between British and U.S. gallons, quarts, pints, bushels, pecks, etc. Some cultured persons are even unaware of the difference between the apothecary's ounce or pound and the avoirdupois ounce or pound."

119. As opposed to the metrical system—monobasic and decimal—the polybasic Anglo-American system is so backward that its preservation until our own time is almost incredible. Indeed it is distinctly inferior to the system divised by Sumerians five thousand years ago! And yet there are still plenty of people—intelligent and cultured—who swear by it and are ready to defend it with that kind of passion which can only be excited and enlisted for irrational causes.

Two main conclusions can be drawn from all this. Firstly, the slowness of human progress in spite of appearences to the contrary. If human inertia can be so obstructive, with regard to mechanical things such as weights and measures, should we wonder at its overpowering strength with regard to such intangible matters—charged with endless memories and emotions and involving as they do vested privileges of every kind—as religion, language, government, peace, and justice?

Secondly, STEVIN's originality and genius, for he saw clearly three centuries and a half ago what many enlightened people of our enlightened age are not yet able to see today.

Cambridge, Mass. GEORGE SARTON.
June 10, 1933.

VIII. — APPENDICES

120. *Bibliography.*

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121. *Iconography.*

The figures of my first Stevin paper being numbered from 1 to 30, those illustrating the present will be numbered from 31 to 52; this for the sake of the index common to both. The pages of the facsimile reprint of STEVIN's Disme are numbered according to their original pagination from 132 to 161. For indications of the sources I use the following abbreviations:

B L	Bodleian Library, Oxford.
B M	British Museum, London.
B S N H	Boston Society of Natural History, Boston, Mass.
H L	Henry E. Huntington Library, San Marino, Cal.
H U L	Harvard University Library, Cambridge, Mass.
L C	Library of Congress, Washington, D. C.
O R B	Observatoire Royal de Belgique, Uccle.
P S B	Preussische Staatsbibliothek, Berlin.
U S B S	United States Bureau of Standards, Washington.

The courtesy of these libraries is duly appreciated. I owe

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Fig. 31. (STEVIN) *De Thiende*. Leiden, 1585 (after BOSMANS, 1924). See § 64.

Fig. 32. (STEVIN) *Disme: The Art of Tenths*. London, 1608 (B M). See § 68 (The word *Disme* is 5 cm. long).

Fig. 33. (J. H. BEYER). *Ein newe und schöne Art der Vollkommenen Visierkunst. Derengleichen hiebevor niemaln in keiner Spraach gesehen worden.* Francfort a.M., 1603 (P S B). See § 97.

Fig. 34. (J. H. BEYER). *Stereometriae inanium nova et facilis ratio, geometricis demonstrationibus confirmata: & necessariis obscuriorum quorundam delineationibus illustrata.* Francfort, 1603 (P S B). See § 97.

Fig. 35. (J. H. BEYER). *Logistica decimalis: Das ist Kunstrechnung der Zehentheyligen Brüchen. Denen Geometris Astronomis, Landtmessern, Ingenieurn, Visirern und insgemein allen Mechanicis und Arithmeticis, zu unglaublicher Leichterung ihrer Mühesamen Rechnungen, Extractionen der Wurtzeln sonderlich auss den Irrationalzahlen auch zur Construction einer newen Tabulae Sinuum und anderer vielerhandt nützlicher canonum, & über die massdienstlich und nothwendig.* Franckfurt a.M., 1619. (The original book is 19 cm. high, 15 cm. wide), (P S B). See § 97.

Fig. 36. (J. H. BEYER). Same book, p. 22, containing the beginning of his history of decimal fractions.

Fig. 37. (J. H. BEYER). *Conometria Mauritiana; Das ist Ein newer Stereometrischer Tractat von der lang-gesuchten und gewündschten Visierung dess vollen und lähren Stücks oder Theyls eines Weinfasses.* Francfort, 1619 (P S B). See § 97. Notice dedication to Prince MAURICE of Orange-Nassau.

Fig. 38. (R. W. = RICHARD WITT). *Arithmeticall questions.* London 1613 (B M). The word Arithmeticall measures 94 mm. See § 69.

Fig. 39. (HENRY LYTE). The Art of Tens. London, 1619 (H L). See § 69.

Fig. 40. (WILHELM VON CALCHUM gñt LOHAUSEN Obristen).

Zusamfassung Etlicher Geometrischen Aufgaben so durch die Rechenkunst allein aufzulösen. Benebenst kurtzem bericht von zehendzahlen. Bremen, 1629 (P S B). The book is 31 cm. high and 18.5 cm. wide. See § 98.

Fig. 41. (WILLIAM BARTON). *Arithmeticke Abreviated. Teaching the art of tennes or decimals to worke all questions in fractions as whole numbers, without reduction : An easier and plainer way than the vulgar.* London, 1634 (H L). See § 69.

Fig. 42. (SAMUEL JEAKE, Senior). *Λογιστικηλογία or Arithmetick surveighed and reviewed.* London, 1696 (L C) 32.5 cm. high. See § 98.

Fig. 43. (CHRISTOFF RUDOLFF). *Exempel Büchlin* (Augsburg), 1530 (P S B). The book is 14 cm. high 9 cm. wide. See § 92.

Fig. 44. A page of RUDOLFF's *Exempel Büchlin*, showing the use of decimal separators (P S B). See § 92.

Fig. 45. (ELIJAH HA-MIZRAḤI). *Sefer ha-mispar.* Constantinople (c. 1532), (B L). See § 92.

Fig. 46. A page of the *Sefer ha-mispar*, showing use of decimal separators (B L). See § 92.

Fig. 47. (ISAAC GREENWOOD). *Arithmetick Vulgar and Decimal.* Boston, 1729 (H U L). The first American treatise on decimal fractions. See § 99.

Fig. 48. Page of GREENWOOD's book, illustrating the decimal scale (H U L). See § 99.

Fig. 49. (GABRIEL MOUTON). *Observationes diametrorum Solis et Lunae.* Lyon, 1670 (U S B S). See § 104. The book is 23 cm. high.

The appendix entitled "*Nova mensurarum geometricarum idea*" (mentioned on the title page) contains the first statement of *both* ideas of the metrical system : decimal progression of all units and universal standard. See § 104.

Fig. 50. (TITO LIVIO BURATTINI). *Misura universale.* Vilna, 1675. (See § 104*bis*). After FAVARO's elaborate memoir of Venice, 1896 (B S N H).

Fig. 51. *L'Arithmétique de* SIMON STEVIN. Leiden, 1585 (O R B). See § 64-66.

Fig. 52. *La Pratique d'arithmétique.* Leiden, 1585 (O R B). See § 64-66. This is the title-page of the second volume of l'*Arithmétique.*

This is followed with a complete facsimile of STEVIN's *Disme* of 1585, p. 132 to 161 of the *Pratique d'arithmétique*.

This facsimile is the seventeenth of a collection of which nos. I to XVI have appeared in *Isis* as follows.—The texts are quoted in chronological order (Roman numbers are the serial numbers of the facsimiles, Arabic numbers refer to the dates and to the volumes of *Isis*).

GEMMA FRISIUS, 1533 (XVI), Isis 22.
PASCAL, 1639 (II), Isis 10.
NEWTON, 1672 (X), Isis 14.
BRADLEY, 1729(XII), Isis 16.
DE MOIVRE, 1733 (I), Isis 8.
BRADLEY, 1748 (XV), Isis 17.
VOLTA, 1800 (XI), Isis 15.
OERSTED, 1820 (III, IV), Isis 10.
S. CARNOT, 1824-32 (VII), Isis 13.
V. BAER, 1827 (XIII), Isis 16.
H. LLOYD, 1833 (XIV), Isis 17.
J. R. MAYER, 1842 (V), Isis 13.
J. P. JOULE, 1843 (VI), Isis 13.
DARWIN, 1859 (VIII), Isis 14.
A. R. WALLACE, 1859 (IX), Isis 14.

122. *Index.*

The nos. 1 to 121 refer to the paragraphs of both papers (1 to 63*bis* to the first paper, 64 to 121 to the second). The nos. 132 to 161 refer to the pages of the facsimile of STEVIN's *Disme* placed at the end of the second paper. Finally the indications Fig. 1 to Fig. 52 refer to the figures and to their legends in the iconographical sections. Figs. 1 to 30 were appended to the first paper, see description in § 63; Figs. 31 to 52 belong to the second paper, see description in § 121.

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Tillet, M., 106.
Tomson, 104.
Trenchant, Jean, 8.
Tropfke, J., 81, 83, 97, 98, 109, 115, 120, 121.
Tuning, Jean, 5, 18, 22, 25.
Turgot, 106.
Ulūgh Beg, 86.
Ursus, R., 81.
Valerio, Luca, 44.
Vetter, Q., 120.
Viète, 93, 94.
Vincent, J., 62.
Virien, see Viry.
Viry, Maurits de, 6.
Vitruvius, 22.
Vivanti, G., 62.
Viviani, Vincenzo, 4.
Vlacq, A., 67.
Waard, Cornelis, de 1, 4, 18, 23, 27, 28, 32.
Wagner, H., 53.
Wallis, J., 120.
Wieleitner, H., 62.
Willem II of Holland, 57.
Willsford, T., 89.
Witelo, 22.
Witt, R., Fig. 38.
Wonder en is gheen wonder, 70.
Woude, W. van der, 4, 5, 62.
Wren, C., 104.
Wright, Edward, 17, 53.
Xylander, 12.
Yang Hui, 84.
Zekī, Ṣāliḥ, 76, 86, 87.
Zittel, K. A. v., 56, 62.

DE

THIENDE

Leerende door onghehoorde lichticheyt allen rekeningen onder den Menfchen noodich vallende, afveerdighen door heele ghetalen fonder ghebrokenen.

Beſchreven door SIMON STEVIN *van Brugghe.*

TOT LEYDEN,

By Chriſtoffel Plantijn

M. D. LXXXV

FIG. 31

DISME:

The Art of Tenths,

OR,

Decimall Arithmetike,

Teaching how to performe all Computations *whatſoeuer, by whole Numbers without* Fractions, by the foure Principles of *Common Arithmetick: namely,* Addition, Subtraction, Multiplication, and Diuiſion.

Inuented by the excellent Mathematician, Simon Stevin.

Published in English with ſome additions by *Robert Norton*, Gent.

Imprinted at London by *S. S.* for *Hugh Aſpley*, and are to be ſold at his ſhop at Saint Magnus corner. 1608.

FIG. 32

Ein newe vnd schöne Art der

Vollkommenen Visier-Kunst:

Derengleichen hiebevor niemaln in keiner Spraach gesehen worden.

Wie man nemlich vielerley vnderschiedne Visierstäbe zurichten/ auch mit denselbigen allerhand regulierte hole Cörper/ sie seyen so groß oder kleyn sie immer mögen/ als mancherley Särcke/ Röhrkästen/ Brunnen/ Faß/ Bütten/ Eymer/ Gläser/ Kugeln/ ꝛc. visieren/ vnd derenthalben gantz leichtlich erkündigen soll.

Denen Kunstliebenden Baw-meistern/ Werckleuten/ Visierern/ Weinhändlern vnd Hauß-hattern zu gutem/ jetzo erst auß Geometrischen bewerten Gründen erfunden/ demonstriert/ vnd klärlich beschrieben: Auch mit eygenmachtem Abriß deren hierzu nothwendigsten Stöcken gezeret:

Durch

Johann-Hartmann Beyern/ Medicum zu Franckfurt am Mayn.

Getruckt zu Franckfurt am Mayn/ durch Paltheniu̇m.

In Verlegung Ionæ Rosen.

M. D. CIII.

Fig. 33

STEREOMETRIÆ INANIVM NOVA ET FACILIS RATIO,

GEOMETRICIS DEMONSTRATIONIBUS confirmata: & necessariis obscuriorum quorundam delineationibus illustrata:

QVA CORPORVM REGVLARIVM OMNIVM, TAM RECTILINEORVM QVAM CVRVILINEORUM capacitates promtissime explorantur.

Authore

IOHANNE-HARTMANNO BEYERO, Reipublicæ Francofurtensis Medico.

FRANCOFVRTI,

In Officina Paltheniana, Impensis Ionæ Rhodii.

ANNO M. DC. III.

Fig. 34

M D CIIL

FIG. 33

ANNO M. DC. III.

FIG. 34

Logistica Decimalis:

Das ist:

KUnst Rechnung der Zehentheyligen Brüchen.

Denen Geometris, Astronomis, Landtmessern/ Ingenieurn/ Visirern/ und ins gemein allen Mechanicis und Arithmeticis, zu vnglaublicher Leichterung ihrer Mühesamen Rechnungen/ Extractionen der Wurtzeln/ sonderlich aus den Irrationalzahlen/ auch zur Constructionen einer newen Tabulæ sinuum, vnd anderer vnterhandē nöhtiglicher canonum, &c. vber die maß dienstlich vnd nothwendig.

Beschrieben / durch

Johann Hartmann Beyern / D. Med. ord. zu Franckfurt am Meyn.

ANNO M. DC. XIX.

Gedruckt zu Franckfurt/

Durch Nicolaum Hoffmann / Zu verlegung Jacob Fischers S. Erben.

FIG. 35

Das Erste Capitul.

Was die Mechanische Kunstrechnung sey: Vnd wie sie erfunden. Auch von Abtheylung dieses Tractätleins.

DJe Mechanische Bruchrechnung wird Logistica decimalis, δεκαδικὴ genandt. Vnnd ist ein Arithmetischer vortheilhafftiger Special-Proceß / wie man bey Mechanischen Abmessungen / vnnd Rechnungen / die vorkommende Brüche/ in eitel Subordinirte zehentheil richten / künstlich bezeichnen/ auch den gantzen Zahlen gleichförmig / in allen speciebus numerationis, vnnd extractionibus radicum, tractiren vnd handeln möge: Zu leichterung der gemeinen mühesamen Rechnung dienende.

Von Erfindung der Zehentheiligen Brüchen.

Zu der Invention dieser Zehentheiligen Brüchen/ ist mir erstlichen Anno 1597. als ich mich je zuweilen (so viel ich anderer meiner Amtsgeschäfften halben Zeit hatte) in den Mathematischen Künsten exercirte/ von den Gestirnkünstlern/ folgender gestalt Anlaß gegeben worden. Ich habe damahln in acht genommen/ daß die Mechanici, wann sie eine vorkommende Quantitet abmessen / gar selten eine gantze Zahl ihrer Grundmaß (als/ Ruthen/ Elen/ Schuch/ Grad/ &c.) antreffen. Vnd derohalben das jenige / was weniger ist / als ein solches Maß / Bruchweiß beyfügen müssen. Wie dann die Landtmesser / was vnter einer Ruthen lang ist / mit Schuhen vnd Zollen: Etliche Visirer/ als Andreas Helmreich / was vnter einer Länge/ oder Tieffpuncten ist mit dreyvierteln/ viertheilen/ fünffzehenden/ achtentheilen/ zwey vnd zwantzig theilen: Vnd die Astronomi ihre Circulbögen / wann sie nngere Theile / als Grad / haben / mit sechtzigtheiligen subordinirten Secunden messen vnd zehlen.

Die Astronomische Art der continuirlich verjüngten Brüchen/ vnter einer gleichen benennung / habe ich vermeinet / daß sie auch bey andern Abmessungen gebraucht werden möchte. Als/ daß man ein gantze Feldruthen

FIG. 36

Conometria Mauritiana;

Das iſt/

EIn newer Stereo-
metriſcher Tractat/ von der lang-geſuchten
vnnd gefundſchten Viſierung deß vollen vnnd lähren
Stücks/ oder Theyls eines Weinfaſſes. Sampt denen darzu
gehörigen Käng-vnd Circultruthen: auch der Circuln/
vnd Circulſtücken Flächtaffeln.

Dem Durchleuchtigen/ Hochgebornen Für-
ſten vnd Herrn/ Herrn Moritzen/ Printzen zu Vra-
nien/ Graven zu Naſſaw/ Catzenelnbogen/
Vianden/ vnd Dietz/ ꝛc.

Zu unterthänigen Ehren
Beſchrieben/ vnd calculirt/
Durch
Johann-Hartmann Beyern: Doct. Medicum Ordi-
narium zu Franckfurt am Meyn.

ANNO M. DC XIX.

Gedruckt zu Franckfurt/ durch Nicolaum Hoffmann/
In verlegung Jacob Fiſchers S. Erben.

FIG. 37

ARITHMETICALL QVESTIONS,

TOVCHING

The Buying or Exchange of Annui-
ties; *Taking of Leaſes for Fines, or yearly*
Rent; Purchaſe of Fee-Simples; Dealing for pre-
ſent or future Poſſeſsions; and other Bargaines and
Accounts, wherein allowance for diſburſing or
forbearance of money is intended;
Briefly reſolued, by means of certain Breuiats.

Calculated by *R. W.* of London, practitioner in
the Arte of NVMBERS.

Examined alſo and corrected at the Preſſe, by
the Author himſelfe.

LONDON,
Printed by *H. L.* for *Richard Redmer*; and are to be ſolde
at his Shoppe at the Weſt-dore of *S. Paules*, at the
Signe of the Starre. 1613.

FIG. 38

The Art of Tens,

OR

DECIMALL

Arithmeticke.

Wherein,

The Art of Arithmeticke

is taught in a moſt exact and perfit method, auoyding the intricacie of *Fractions.*

Exerciſed by HENRY LYTE *Gentleman,*

And by him ſet forth for his Countries good.

LONDON,
Printed by EDWARD GRIFFIN dwelling in the little *Old Bayly* neere the ſigne of the *Kings head.* 1619.

FIG. 39

FIG. 40

Arithmeticke Abreviated.

TEACHING THE ART OF TENNES OR Decimals to worke all Queſtions in Fractions as whole Numbers, without Reduction: An eaſier and Plainer way than the vulgar.

Shewing the uſe alſo of *Napiers* Bones, by which Multiplication and Diviſion is performed without charging the Memory at all to thoſe that will make uſe of them.

As alſo the extracting of the Square and and Cube Roots, with divers Applications thereof.

Printed at *London* for *James Boler*, and *William Luggard*, and are to be ſold at the Marigold in *Pauls* Church-yard. 1634.

a

FIG. 41

ΛΟΓΙΣΤΙΚΗ ΛΟΓΙΆ
OR
ARITHMETICK
Surveighed and Reviewed:

In Four BOOKS.

VIZ.

1 Book { 1 Part Integers. 2 Part Fractions.
2 Book { 1 Part Geodaticals. 2 Part Figurals.
3 Book { 1 Part Decimals. 2 Part Aſtronomicals. 3 Part Logarithmes. 4 Part Cofficks. 5 Part Surds. 6 Part Species.
4 Book { 1 Part Ratios. 2 Part Proportions disjunct. 3 Part Proportions continued. 4 Part Æquations.

Wherein the Nature of Numbers abſolutely abſtract, generally and ſpecially contract, with their Simple and Comparative Elements, are plainly declared, and fully handled.

Every Part furniſhed with ſuch neceſſary Rules, Caſes, Theoremes, Queſtions, Obſervations, and Varieties of Operations, as principally to them belong, and for the moſt part Illuſtrated by lively Tables, Diagrams, and very many Examples: Together with divers Etymologies, Symbolies, Characters, and Abbreviations for Artificial Termes, Words, Names, and Demonſtrations, and all digeſted into ſo ſuccinct, and orderly a Method, and delivered in ſo familiar a Style, as may bebe Mean Capacities, and if practically applied, become more than ordinarily Uſeful both in Mechanical and Mathematical Arts and Sciences.

By SAMUEL JEAKE Senior.

Non parta Studio ægemur, &c.

LONDON,
Printed by *J. R.* and *J. D.* for *Walter Kettilby* at the *Biſhops Head* in St. *Paul's Church-Yard*, and *Richard Mount* on *Tower-Hill*, neer the *Poſtern*, M DC XCVI

FIG. 42

Fig. 41

Fig. 42

Exempel Büchlin

Rechnung belangend. darbey / ein nutzliche Instruction / wölicher gestalde die vergleychnus / der Elnmaß durch den Zirckel / der Pfund durch abwegen / der Thiayd / Weyn / vnd Olmaß ꝛc. Durch abfechtenn der Müntz / durchganghafften yren werde / gegen einander zů erlernen vñ ergründe sey.

Jů Wien in Osterreych / durch Christoffen Růdolff / seynē schülern zů sonderer nutzung auch allen handthierungen personen zů nutz vnd gůtem verfertigt.

M. D. XXX.

Fig. 43

3>5. 18>5.
fl. 393|>5 haupegůt vñ gewin des erstē jars.
1968>5
413|43>5 Andern
206>18>5
434|1093>5 Dritten
21>05468>5
455|8148843>5 Vierdten
22>90>4218>5
478|60558593>5 Fünfften
23 9302>92968>5
502|53586523 43>5 Sechsten
25 126>93261>18>5
522>|662658496093>5 Sibenden
26383132924804 68>5
554|045>91420808 43>5 Achteten
27>022895>10449218>5
581|>4808099194335 93>5 Nevndē
29 08>4040905 9>16>968>5
fl.610|835485041540 52>343>5 Zehētē
ß 6|68>8803323242 18>5000
℔ 20|6164099 69>2656250000.
>2 Die 120 fl trage 2 jar p haupegůt zins vnd zinszins 132 fl 2ß 12 ₰. bringt zinß vñ zinszins 12 fl 2ß 12 ₰. Darnach die 250 fl tragē 3 jar haupetg. zins vñ zinszinß 289 fl 3ß. > ₰½. Vnd ist halber zins des vierdtē jars > fl 1ß 26. ₰ 18

(2)

ARITHMETICK

Vulgar and *Decimal*:

Charlestown's book 1727

WITH THE

APPLICATION

THEREOF TO

A VARIETY of CASES

IN

Trade, and *Commerce*.

BOSTON: N. E.

Printed by S. KNEELAND and T. GREEN, for T. HANCOCK at the Sign of the Bible and Three Crowns in *Ann-street*. MDCCXXIX.

FIG. 47

NOTATION.

The TABLE.

Whole Numbers						Decimal Parts.						
6	5	4	3	2	1	,	1	2	3	4	5	6
&c.	*Hundred of Thousands.*	*Tens of Thousands.*	*Thousands.*	*Hundreds.*	*Tens.*	*Units Place.*	*Parts of Ten, or* $\frac{1}{10}$.	*Parts of a Hundred*	*Parts of a Thousand*	*Parts of Ten Thousand*	*Parts of a Hundred Thousand*	*Parts of a Million* &c.

The USE

Or this *Table* will appear in the following *Observations*.

I.

THAT *Decimal Fractions* are always seperated from *whole Numbers* by some distinguishing Mark, as a *Comma*, a *Period*, or the like. So 614321. are *Integers*; and ,123456 *Decimal Parts* And from hence is derived a *Universal Rule* to distinguish *Integers* from *Decimals*, in any *mix'd Sums* whatsoever, viz. *That the Integers always lay on the left, and the Decimals on the Right Hand of the Separatrix.*

II.

THE *Denominator* is always omitted in the *Notation* of *Decimal Fractions*; Thus, ,1 is the *Notation* of $\frac{1}{10}$.

FIG. 48

OBSERVATIONES

DIAMETRORUM SOLIS ET LUNÆ APPARENTIUM,

Meridianarumque aliquot altitudinum Solis & paucarum fixarum.

Cum tabulâ declinationum Solis conſtructa ad ſingula graduum Eclipticæ ſcrupula prima.

Pro cujus, & aliarum tabularum conſtructione ſeu perfectione, quædam numerorum proprietates non inutiliter deteguntur.

HUIC ADJECTA EST

BREVIS DISSERTATIO

De dierum naturalium inæqualitate, & de tempore æquationis.

UNA CUM NOVA MENSURARUM GEOMETRICARUM IDEA.

Novique methodo eas communicandi, & conſervandi in poſterùm ubique alterationis ſ

Auctore GABRIELE MOUTON *Lugdunenſi, Sacerdote in Eccleſia Collegiata S. Paulo.*

LUGDUNI;

Ex Typographiâ MATTHÆI LIBERAL, in viâ Mercatoriâ, ſub Signo Boni ductus.

M. DC. LXX.

Cum Approbatione & permiſſu Superiorum.

DESPLACES.

FIG. 49

MISVRA VNIVERSALE

OVERO TRATTATO

NEL QVAL SI MOSTRA

come in tutti li Luoghi del Mondo ſi può trouare una MISVRA, & un PESO VNIVERSALE ſenza che habbiano relazione con niun'altra MISVRA, e niun altro PESO, & ad ogni modo in tutti li luoghi ſaranno li medeſimi, e ſaranno inalterabili, e perpetui fin tanto che durerà il MONDO.

DI TITO LIVIO BVRATTINI

La Miſura ſi può trouare in un hora di tempo e queſta ci moſtra quanto graue deu'eſſere il PESO

Data MISVRA ſi trouano ancora le MISVRE CORPOREE per miſurare le coſe aride, e le liquide.

IN VILNA

Nella ſtamperia de Padri Franceſcani L'Anno M.DCLXXV.

FIG. 50

L'ARITHMETIQVE
DE SIMON STEVIN
DE BRVGES:

A

Contenant les computations des nombres Arithmetiques ou vulgaires :

Auſsi l'Algebre, auec les equations de cinc quantitez.

Enſemble les quatre premiers liures d'Algebre de Diophante d'Alexandrie, maintenant premierement traduicts en François.

Encore vn liure particulier de la Pratique d'Arithmetique, contenant entre autres, Les Tables d'Intereſt, La Diſme; Et vn traicté des Inconmenſurables grandeurs : Auec l'Explication du Dixieſme Liure d'Euclide.

A LEYDE,
De l'Imprimerie de Chriſtophle Plantin.
cIↃ. IↃ. LXXXV.

FIG. 51

LA
PRATIQVE
DARITHMETIQVE
DE
SIMON STEVIN
De Bruges.

A LEYDE,
En l'Imprimerie de Chriſtophle Plantin
cIↃ. cI. LXXXV.

FIG. 52

LA DISME.

Enſeignant facilement expedier par nombres entiers ſans rompuz, tous comptes ſe rencontrans aux affaires des Hommes.

Premierement deſcripte en Flameng, & maintenant conuertie en François, par SIMON STEVIN *de Bruges.*

AVX ASTROLOGVES ARPENTEVRS, MESVREVRS DE TAPISSERIE, GAVIEVRS, STEREOMETRIENS EN general, Maiſtres de monnoie, & a tous Marchans: SIMON STEVIN Salut.

QVELCVN *voiant la petiteſſe de ce liuret, & la comparant à la grandeur de vous mes* Treſhonnorez Seigneurs, *auſquels il eſt dedié, eſtimera peut eſtre noſtre concept abſurd; Mais ſ'il conſidere la Proportion, qui eſt, comme la petite quantité de ceſtui ci, à l'humaine imbecillité de ceux la, ainſi ſes grandes vtilitez, à leurs hauts & ingenieux entendemens, ſe trouuera auoir faict comparaiſon des termes extremes, leſquels ne la permettent en conuerſion de proportion quelconque. Soit doncques le troiſieſme au quatrieſme. Mais que ſera ce propoſé? d'auenture quelque inuention admirable? non certes, mais choſe ſi ſimple qu'elle ne merite quaſi le nom*

230 G. SARTON

d'inuention; car comme l'homme ruſtique, & lourd, trouue bien d'auenture quelque grand treſor, ſans y auoir vſé de ſcience, tout ainſi le ſemblable eſt il aduenu en ceſt affaire : Pourtant ſi quelcun me vouluſt eſtimer pour vanteur de mon entendement à cauſe de l'explication de ces vtilitez; ſans doubte il demonſtre, ou qu'il n'y a en lui ny iugement, ny intelligence, de ſçauoir diſcerner les choſes ſimples des ingenieuſes, ou qu'il ſoit enuieux de la proſperité commune; mais quoi qu'il en ſoit, il ne faut pas omettre l'vtilité de ceſtui ci, pour l'inutile calomnie de ceſtui la. Or comme le marinier aiant d'auenture trouué quelque Iſle incognue, declare franchement au Roi toutes ſes richeſſes, comme d'auoir beaux fruicts, precieux mineraux, plaiſantes contrees, &c. ſans que cela lui ſoit reputé pour philautie; ainſi nous parlerons ici librement de la Grande vtilité de ceſte inuention, ie di Grande, voire plus Grande que ie n'eſtime qu'aucun de vous autres attende, ſans toutesfois me glorifier du mien.

Veu doncques que la matiere de ceſte DISME (la cauſe duquel nom ſera declairée, par la ſuiuante

uante premiere definition) eſt nombre, l'vtilité des effects de laquelle, vous M^rs eſt aſſes notoire par voz continuelles experiences, il ne ſera point meſtier d'en faire beaucoup de parolles; Car ſ'il eſt Aſtrologue, il ſçait que le monde eſt deuenu par les computations Aſtronomiques (car elles enſeignent au Pilote l'eleuation de l'Equateur, & du Pole, par le moien de la table des declinations du Soleil, l'on deſcript par icelles la vraie longitude & latitude des lieux, &c.) vn paradis, abondant en pluſieurs lieux, de ce que toutesfois la terre n'y peut point produire. Mais comme le doux n'eſt iamais ſans l'amer, le trauail de telles computations ne lui ſera point caché, à cauſe des laborieuſes multiplications, & diuiſions, qui procedent de la ſoixantieſme progreſſion des Degrez, Minutes, Secondes, Tierces, &c. Mais ſ'il eſt Arpenteur, il ſçaura le grand benefice que le monde reçoit de ſa ſcience, par laquelle ſ'euitent pluſieurs difficultez & noiſes, qui ſ'eleueroient tournellement, à cauſe de l'incognue capacité des terres; Outre cela il ne ignore pas (principalement celui auquel les affaires ſont grandes) les ennuieuſes mul-

ſes multiplications, qui procedent des Verges, Pieds, & ſouuent Doigts, l'vn par l'autre, qui n'eſt pas ſeulement moleſte, mais (combien toutesfois que le meſurer & autres choſes precedentes fuſſent bien expediees) ſouuent cauſe d'erreur, tendant au grand dommage de l'vn ou de l'autre. Auſſi à la ruine de la bonne renommée de l'Arpenteur : Et ainſi des Maiſtres des monnoies, Marchans, & chaſcun au ſien : Mais d'autant que ceux la ſont plus dignes, & les voies pour y paruenir plus labourieuſes, d'autant plus grande eſt ceſte deſcouuerte DISME oſtant toutes ces difficultez ; Mais comment ? Elle enſeigne (à fin de dire beaucoup en vn mot) d'expedier facilement ſans nombres rompuz, tous comptes qui ſe rencontrent aux affaires des Humains : de ſorte que les quatre principes d'Arithmetique que l'on appelle Aouſter, Soubſtraire, Multiplier & Diuiſer par nombres entiers, pourront ſatisfaire à tel effect : Cauſant ſemblable facilité à ceux qui vſent des gettons. Or ſi par tel moien ſera gaigné le precieux temps ; Si par tel moien ſera ſauué, ſe qui ſe perderoit autrement ; Si par tel moien

moien ſera oſté labeur, noiſe, erreur, dommage, & autres accidens communement aioinctz à ceux ci, ie le mectz volontiers à voſtre iugement.

Quant à ce que quelcun me pourroit dire, que pluſieurs inuentions ſemblent bonnes au premier regard, Mais quand on ſ'en veut ſeruir, l'on n'en peut rien effectuer, & comme il auient ſouuent aux chercheurs de ſorts mouuemens, qui ſemblẽt bons en petites preuues, mais aux grandes, ou a l'effect, ils ne vallent pas vn feſtu: Nous lui reſpondons qu'il n'y a ici telle doubte, parce que l'experience ſ'en faict tournellement en la choſe meſme, A ſçauoir par diuers experts Arpenteurs Hollandois, auſquels nous l'auons declaré, leſquels (laiſſans ce qu'ilz auoient inuenté chaſcun à ſa maniere, pour amoindrir le trauail de leurs computations) l'vſent à leur grand contentement, & par tel fruict comme la Nature teſmoigne ſ'en deuoir neceſſairement ſuiure: Le meſme auiendra à vn chaſcun de vous autres mes Treſhonnorez Seig^rs qui feront comme eux, viuez ce pendant en toute felicité.

ARGVMENT.

LA Disme à deux parties, Definitions, & Operation. En la premiere partie se declairera par la premiere Definition, quelle chose soit Disme; Par la seconde, troisiesme & quatriesme, que signifie Commencement, Prime, Seconde, &c. & nombres de Disme.

En l'operation se declairera par quatre propositions, l'Addition, Soubstraction, Multiplication, & Diuision des nombres de Disme, Dequoi l'ordre se peut representer succinctement par telle table :

La Disme à deux parties.
- *Definitions touume quelle chose soit*
  - *Disme.*
  - *Commencement.*
  - *Prime, Seconde, etc.*
  - *Nombre de Disme.*
- *Operation de*
  - *l'Addition.*
  - *Soubstraction.*
  - *Multiplication.*
  - *Diuision.*

A la fin du precedent sera encore appliqué vne Appendice, declarant l'vsage de la Disme par quelques exemples és choses.

LA

LA PREMIERE PARTIE DE LA DISME DES DEFINITIONS.

DEFINITION 1.

DISME est vne espece d'Arithmetique, inuentée par la Disiesme progression, consistente es characteres des ciffres, par lesquels se descript quelque nombre, & par laquelle l'on depesche par nombres entiers sans rompuz, tous comptes se rencontrans aux affaires des hommes.

EXPLICATION.

Soit quelque nombre de mille cent & onze, descript par characteres des cyffres en ceste sorte 1111, ausquels appert que chasque 1 est la dixiesme part de son prochain charactere precedent. Semblablement en 2378, chasque vnité du 8, est la dixiesme de chasque vnité du 7. Et ainsi de tous les autres. Mais parce qu'il est conuenable que les choses desquelles on veut traicter, aient des noms, & que ceste maniere de computation est trouuée par consideration de telle dixiesme ou disme progression, voire qu'elle consiste entierement en icelle, comme apparoistra ci apres, nous nommons ce traicté proprement & conuenablement la DISME, par la mesme on peut operer auec nombres entiers sans rompuz en tous les comptes se rencontrans

trans en noz affaires, comme ſera demonſtré au ſuiuant.

DEFINITION II.

Tout nombre propoſé ſe dict COMMENCEMENT, *ſon ſigne eſt tel* ⓒ.

EXPLICATION.

Par exemple quelque nombre propoſé de trois cens ſoixantequatre, nous le nommons trois cens ſoixantequatre COMMENCEMENS, les deſcripuant en ceſte ſorte 3 6 4 ⓒ. Et ainſi de tous autres ſemblables.

DEFINITION III.

Et chaſque dixieſme partie de l'vnité de commencement nous la nommons PRIME, *ſon ſigne eſt tel* ①; *& chaſque dixieſme partie de l'vnité de prime nous la nommons* SECONDE, *ſon ſigne eſt tel* ②. *Et ainſi des autres chaſque dixieſme partie, de l'vnité de ſon ſigne precedent, touſiours en l'ordre vn d'auantage.*

EXPLICATION.

Comme 3 ① 7 ② 5 ③ 9 ④, c'eſt à dire; 3 *Primes* 7 *Secondes* 5 *Tierces* 9 *Quartes*; & ainſi ſe pourroit proceder en infini. Mais pour dire de leur valeur, il eſt notoire, que ſelon ceſte definition, leſdicts nombres ſont $\frac{3}{10}\ \frac{7}{100}\ \frac{5}{1000}\ \frac{9}{10000}$, enſemble $\frac{3759}{10000}$. Semblablement 8 ⓒ 9 ① 3 ② 7 ③ vallent 8 $\frac{9}{10}\ \frac{3}{100}\ \frac{7}{1000}$, enſemble

ſemble 8 $\frac{937}{1000}$. Et ainſi d'autres ſemblables. Il faut auſſi ſçauoir que nous n'vſons en la DISME d'aucuns nombres rompuz, auſſi que le nombre de multitude des ſignes, excepté ⓒ, n'excede iamais le 9. Par exemple nous n'eſcripuons pas 7 ① 12 ②, mais en leur lieu 8 ① 2 ②, car ils vallent autant.

DEFINITION IIII.

Les nombres de la precedente ſeconde & troiſieſme Definition ſe diſent en general NOMBRES DE DISME.

Fin des Definitions.

SECONDE PARTIE DE LA DISME

DE L'OPERATION.

PROPOSITION I, DE L'ADDITION.

ESTant donnez nombres de Disme à aiouſter : Trouuer leur Somme.

Explication du donné. Il y a trois ordres de nõbres de Disme, deſquels le premier 27⓪8①4②7③, le deuxieſme 37⓪8①7②5③, le troiſieſme 875⓪7①8②2③.

Explication du requis. Il nous faut trouuer leur Somme. ***Conſtruction.*** On mettera les nombres donnez en ordre comme ci ioignant, les aiouſtant ſelon la vulgaire maniere d'aiouſter nombres entiers, en ceſte ſorte:

⓪	①	②	③
	2	7	8 4 7
	3	7	6 7 5
8	7	5	7 8 2
9	4	1	3 0 4

Donne Somme (par le 1 probleme de l'Arithmetique) 941304, qui ſont (ce que demonſtrent les ſignes deſſus les nombres) 9 4 1 ⓪ 3 ① 0 ② 4 ③. Ie di que les meſmes ſont la Somme requiſe. ***Demonſtration.*** Les 27⓪8①4②7③ donnez, ſont (par la 3^e^ definition) $27\frac{8}{10}, \frac{4}{100}, \frac{7}{1000}$, enſemble $27\frac{847}{1000}$, & par meſme raiſon les 37⓪6①7②5③ vallent $37\frac{675}{1000}$, & les 875⓪7①8②4③ feront $875\frac{782}{1000}$, leſquels trois nombres comme $27\frac{847}{1000}$, $37\frac{675}{1000}$, $875\frac{782}{1000}$, ſont enſemble (par le 10^e^ probleme de l'Arith.) $941\frac{304}{1000}$, mais autant vaut auſſi la ſomme 941⓪3①0②4③, c'eſt

c'eſt doncques la vraiè Somme, ce qu'il falloit demonſtrer. ***Concluſion.*** Eſtant doncques donnez nombres de Diſme à aiouſter, nous auons trouué leur Somme, ce qu'il falloit faire.

NOTA. Si aux nombres donnez defalloit quelque ſigne de leur naturel ordre, on emplira ſon lieu par le diffaillant. Soient par exemple les nombres donnez 8⓪5①6②, & 5⓪7②, auquel dernier defaut le ſigne de l'ordre ①. Lon mettera en ſon lieu 0①, prenant alors comme pour nombre donné 5⓪0①7②, les aiouſtant comme ci deuant en ceſte ſorte:

⓪	①	③
	8	5 6
	5	0 7
1	3	6 3

Ceſt auertiſſement ſeruira auſſi aux trois propoſitions ſuiuantes, la ou il faut touſiours emplir l'ordre des figures diffaillantes, comme nous auons faict en ceſt exemple.

PROPOSITION II, DE LA SOVBSTRACTION.

ESTant donné nombre de Diſme duquel on ſoubſtraict, & à ſoubſtraire : Trouuer leur Reſte.

Explication du donné. Soit le nombre duquel on ſoubſtraict 237⓪5①7②8③, & à ſoubſtraire 59⓪7①4②9③. ***Explication du requis.*** Il faut trouuer leur reſte. ***Conſtruction.*** On mettera les nombres donnez en ordre comme ci ioignant, ſoubſtrahant ſelon la vulgaire maniere de ſoubſtraction par nombres entiers, en ceſte ſorte:

⓪	①	②	③
2	3	7	5 7 8
	5	9	7 4 9
1	7	7	8 2 9

Reſte

Reſte (par le 2 probleme de l'Arithmetique) 177819 qui ſont ce que denotent les ſignes par deſſus les nombres) ① ⑦ ⑦ ⓪ ⑧ ① ② ③ ⑨ ⓪ ; le di que les meſmes ſont la reſte requiſe. *Demonſtration.* Les 237 ⓪ 5 ① 7 ③ 8 ⓪, ſont par la 3e definition de ceſte Diſme) $237\frac{5}{10}, \frac{7}{100}, \frac{8}{1000}$, enſemble $237\frac{578}{1000}$; Et par meſme raiſon les 59 ⓪ 7 ① 4 ② 9 ③ vallent $59\frac{749}{1000}$, leſquelles ſoubſtraicts de $237\frac{578}{1000}$, reſte (par le 10e probleme de l'Arithmetique) $177\frac{829}{1000}$. Mais autant vallent leſdictes ① ⑦ ⑦ ⓪ ⑧ ① ② ⑨ ③, c'eſt doncques la vraie Reſte ce qu'il falloit demonſtrer. *Concluſion.* Eſtant doncques donné nombre de Diſme duquel on ſoubſtraict, & à ſoubſtraire, nous auons trouué leur reſte, ce qu'il falloit faire.

PROPOSITION III, DE LA MVLTIPLICATION.

EStant donné nombre de Diſme à multiplier, & multiplicateur: Trouuer leur produict.

Explication du donné. Soit le nombre à multiplier 32 ⓪ 5 ① 7 ②, & multiplicateur 89 ⓪ 4 ① 6 ②. *Explication du requis.* Il faut trouuer leur produict. *Conſtruction.* On mettera les nombres donnez en ordre comme ci ioignant, multipliant ſelon la vulgaire maniere de multiplication par nombres entiers, en ceſte ſorte:

				⓪	①	②
			3	2	5	7
			8	9	4	6
		1	9	5	4	2
	1	5	0	2	8	
	2	9	3	1	5	
2	6	0	5	6		
2	9	1	3	7	1	2
				⓪	①	②

Donne

Donne produict (par le 3e probleme de l'Arithmetique) 29137122. Or pour ſçauoir que ce ſont, on aiouſtera les deux derniers ſignes donnez, l'vn ②, & l'autre auſſi ②, ſont enſemble ④, nous dirons donc que le ſigne du dernier charactere du produict ſera ④, lequel eſtant cogneu, tous les autres ſeront notoires, à cauſe de leur ordre continu; De ſorte que 29137 ⓪ 7 ① 1 ③ 2 ③ 2 ④ ſont le produit requis. *Demonſtration.* Le nombre donné à multiplier 32 ⓪ 5 ① 7 ③, faict (comme appert par la 3e definition de ceſte Diſme) $32\frac{5}{10}, \frac{7}{100}$, enſemble $32\frac{57}{100}$, & par meſme raiſon le multiplicateur 89 ⓪ 4 ① 6 ②, vaut $89\frac{46}{100}$, par le meſme multiplié ledict $32\frac{57}{100}$, donne produict (par le 12e probleme de l'Arithmetique) $2913\frac{7122}{10000}$; mais autant vaut auſſi ledict produict 29137 ⓪ 7 ① 1 ③ 2 ③ 2 ④, c'eſt donc le vrai produict, ce qu'il nous falloit demonſtrer. Mais pour dire maintenant la raiſon pourquoi ③ multipliée par ②, donne produict ④ (qui eſt la ſomme de leurs nombres) Item pourquoi ④ par ⑤ donne produict ⑨, & pourquoi ⓪ par ③, donne ③ &c. Prennons $\frac{2}{10}$ & $\frac{1}{100}$ (qui ſont par la 3e definition de ceſte Diſme 2 ① 3 ②) leur produict eſt $\frac{6}{10000}$, qui vallent par ladicte troiſieſme definition, 6 ③. Multipliant doncques ① par ②, le produict eſt ③, à ſçauoir vn ſigne compoſé de la ſomme des nombres des ſignes donnez.

Concluſion.

Eſtant doncques donné nombre de Diſme à multiplier, & multiplicateur, nous auons trouué leur Produict ce qu'il falloit faire.

NOTA. Si le dernier ſigne du nombre à multiplier fuſt inegal au dernier ſigne du multiplicateur; par exemple l'vn 3④7⑤8④, l'autre 5①4②, l'on ſera comme deſſus, & la diſpoſition des caracteres de l'operation ſera telle:

④⑤②
3 7 8
5 4 ③
1 5 1 2
1 8 9 0
2 0 4 1 2
④⑤④⑦⑧

PROPOSITION IIII, DE LA DIVISION.

ESTant donné nombre de Diſme à diuiſer & diuiſeur: Trouuer leur Quotient.

Explication du donné. Soit le nombre à diuiſer 3⓪4①4②3③5④2⑤, & le diuiſeur 9①6③. *Explication du requis.* Il nous faut trouuer leur quotient. *Conſtruction.* On diuiſera les nombres donnez (omettant leurs ſignes) ſelon la vulgaire maniere de diuiſer par nombres entiers ainſi:

Donne Quotient (par le 4e probleme de l'Arithmenique) 3587. Or pour ſçauoir que ce ſont, le dernier ſigne du diuiſeur qui eſt ③, ſe ſoubſtraira du dernier ſigne du nombre à diuiſer, qui eſt ⑤, reſte ③, pour le ſigne du dernier charactere du Quotient, qui eſtant ainſi cogneu, tous les autres ſeront auſſi manifeſtes, à cauſe de leur continu ordre, de ſorte que 3⓪5①8②7③, ſont le Quotient requis. *Demonſtration.* Le nombre donné à diuiſer

1
1 8
1 6 4
1 6 1 7 ⓪①②③
4 4 3 5 1 (1 5 8 7
6 6 6 6
5 5 5

3⓪4①4②3③5④2⑤, faict (comme appert par la troiſieſme definition de ceſte Diſme) $3\frac{4}{10}\frac{4}{100}\frac{5}{1000}\frac{2}{10000}$, enſemble $3\frac{44352}{100000}$, & par la meſme raiſon le diuiſeur 9①6②, vaut $\frac{96}{100}$, par lequel diuiſé leſdicts $3\frac{44352}{100000}$, donne quotient (par le 33e probleme de l'Arithmetique) $4\frac{387}{1000}$, mais autant vaut ledict Quotient 3⓪5①8②7③, c'eſt donc le vrai quotient, ce qu'il falloit demonſtrer. *Concluſion.* Eſtant doncques donné nombre de Diſme à diuiſer, & diuiſeur, nous auons trouué leur Quotient, ce qu'il falloit faire.

NOTA I. Si les ſignes du diuiſeur fuſſent plus hauts que les ſignes du nombre à diuiſer, l'on mettera ioignant le nombre à diuiſer autant des 0 qu'on veut, ou autant qu'il ſera meſtier.

Par exemple 7③, ſont à diuiſer par 4⑤; ie mects pres le 7 quelques 0 ainſi 7000, les diuiſant comme deſſus en ceſte ſorte: Donne quotient 1750⓪.

7 0 0 0 (1 7 5 0 ⓪
4 4 4 4

Il auient quelques fois que le quotient ne ſe pourra expliquer par nombres entiers, comme 4①, diuiſees par 3②, en ceſte ſorte:

La ou il appert qu'il y en ſortiront infiniment des trois, reſtant touſiours $\frac{1}{3}$. En tel accident l'on peut approcher ſi pres, comme la choſe le requiert omettant le reſidu. Il eſt bien vrai que 1⓪3①3②, ou 1⓪3①3③3$\frac{1}{3}$③, &c. ſeroit le parfaict requis, mais noſtre intention eſt d'operer en ceſte Diſme, par nombres tous entiers, car nous voions

1 1 1 (1 ⓪①②
4 4 4 4 0 0 0 (1 3 3 3
3 3 3 3

à ce qui ſe obſerue aux negoces des hommes, la ou on ne faict point compte de la milliesme partie d'vne maille, d'vn grain, &c. comme le ſemblable eſt ſouuent vſé par les principaux Geometriens & Arithmeticiens, en comptes de grande conſequence : Comme Ptolemée & Iehan de Montroial, n'ont pas deſcript leurs tables des arcs & chordes, ou des ſinus, par l'extreme parfection (combien qu'il eſtoit poſſible de le faire par nombres multinomies) à cauſe que ceſte imparfection (conſiderant la fin d'icelles tables) eſt plus vtile que telle parfection.

NOTA 2. Les extractions de toutes eſpeces de racines, ſe peuuent auſſi faire par ces nombres de Diſme. Par exemple, pour extraire racine quarrée de 5 ② 2 ③ 9 ④, l'on beſoignera ſelon la vulgaire maniere d'extraction en ceſte ſorte :

Et la racine ſera 2 ① 3 ②, car la moitie du dernier ſigne des nombres donnez, eſt touſiours le dernier ſigne de la racine; Pourtant ſi le dernier ſigne donné fuſt de nombre imper, l'on y aiouſtera ſon ſigne prochain ſuiuant, & ſera alors de nombre per, puis on extraira la racine comme deſſus.

	1
5	2 9
2	3
	4

Semblablement en l'extraction de racine cubique, le tiers du dernier ſigne donné, ſera touſiours le ſigne de la racine, & ainſi de toutes autres eſpeces de racines.

Fin de la Diſme.

APPENDICE.

PREFACE.

PVIS que nous auons deſcript ci deuant la Diſme, nous viendrons maintenant à l'vſage d'icelle, demonſtrans par 6 Articles, comment tous comptes ſe rencontrans aux affaires des hommes, ſe peuuent facilement expedier par icelle, commençant premierement (comme elles ont auſſi eſté premierement miſes en œuure) aux computations d'Arpenterie comme ſ'enſuit.

ARTICLE I. DES COMPVTATIONS DE L'ARPENTERIE.

L'ON nommera la verge auſſi *Commencement*, qui eſt 1 ⓪ la partiſſant en dix parties egales, deſquelles chaſcune ſera 1 ①, puis ſe partira chaſcune *Prime* autrefois en dix parties egales, deſquelles chaſcune ſera 1 ②, & ſi on requiert les diuiſions plus petites, on diuiſera chaſque 1 ③ autrefois en dix parties egales, & chaſcune vaudra 1 ④, procedant ainſi plus auant ſ'il fuſt beſoing, mais quant à l'Arpenterie, les parties en *Secondes* ſont aſſez petites, mais pour les choſes qui requierent la meſure plus iuſte, comme toiſés de plomb,

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Corps, &c. l'on y peut vſer des *Tierces*. Quant à ce que la plus part des Arpenteurs n'vſent pas de verge, ains vne chaiſne de trois, quatre, ou cinc verges, ſignans ſur le baſton de leur croix rectangulaire, quelques cinc ou ſix pieds auec leur doigts, le ſemblable ſe peut faire ici, car au lieu d'iceux cinc ou ſix pieds auec leurs doigts, l'on peut mettre ſix ou cinc *Primes* auec leurs *Secondes*.

Ceci eſtant ainſi preparé, l'on vſera en meſurant de ces parties, ſans prendre egard aux pieds ou doigts que contient la verge ſelon la couſtume du païs, & ce qui ſe debura Aiouſter, Soubſtraire, Multiplier ou Diuiſer ſelon ceſte meſure, ſe fera ſelon la doctrine des precedens exemples.

Par exemple, il faut aiouſter quatre triangles, ou ſuperfices de terre, deſquelles la premiere 345 ⊙ 7 ① 2 ②, La deuxieſme 872 ⊙ 5 ① 3 ③, La troiſieſme 615 ⊙ 4 ① 8 ②, La quatrieſme 956 ⊙ 8 ① 6 ②, les meſmes aiouſtez ſelon la maniere declarée à la premiere propoſition de ceſte Diſme en ceſte ſorte :

Leur ſomme ſera 2790 ⊙ ou verges 5 ① 9 ③, leſdictes verges parties ſelon la couſtume, par autant qu'il y a des verges en vn Arpent, on aura les arpens requis. Mais ſi l'on veut ſçauoir combien de pieds & doigts ſont les 5 ① 9 ③ (ce que l'Arpenteur ne fera qu'vne fois, à la fin du compte qu'il liure aux proprietaires, combien que la pluſpart d'eux, eſtiment inutile d'y faire mention de pieds ou doigts) on verra ſur la verge combien de pieds & doigts (qui ſont marquez ioignant

	⊙	①	②
	3	4	5	7	2
	8	7	2	5	3
	6	1	5	4	8
	9	5	6	8	6
	2	7	9	0	5	9

ioignant les dixieſmes parties ſur vn autre coſté de la verge) ſ'accordent aux meſmes.

Au ſecond, eſtant à ſoubſtraire 57 ⊙ 3 ① 2 ③, de 32 ⊙ 5 ① 7 ③, l'on beſoignera ſelon la ſeconde propoſition de ceſte Diſme en ceſte ſorte :

	⊙	①	②
	5	7	3	2
	3	2	5	7
	2	4	7	5

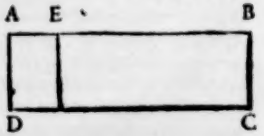
Et reſtent 24 ⊙ ou verges 7 ① 5 ②.

Au troiſieſme, eſtant à multiplier (à cauſe des coſtez de quelque triangle ou quadrangle) 8 ⊙ 7 ① 3 ②, par 7 ⊙ 5 ① 4 ③, l'on fera ſelon la 3e propoſition de ceſte Diſme en ceſte ſorte :

	⊙	①	②
		8	7	3
		7	5	4
	3	4	9	2
	4	3	6	6	
6	1	1	1		
6	5	8	2	4	2
	⊙	①	②	③	④

Et donnent produict ou ſuperfice 65 ⊙ 8 ①, &c.

Au quatrieſme, Soit A B C D, quelque quadrangle rectangle, duquel il faut couper 367 ⊙ 6 ①, & le coſté A D faict 26 ⊙ 3 ①. La demande eſt combien l'on meſurera depuis A vers B, pour couper (i'entens par vne ligne parallele auec A D) leſdictes 367 ⊙ 6 ①.



L'on partira 367 ⊙ 6 ①, par 26 ⊙ 3 ①, ſelon la quatrieſme propoſition de ceſte Diſme ainſi :

Donne quotient pour la requiſe longueur de A vers B, laquelle ſoit A E, 13 ⊙ 9 ① 7 ③.

Et ſi l'on veut on pourra approcher plus pres (cõbien qu'il ne ſemble pas beſoing) par la premiere note de ladicte quatrieſme propoſition, les demonſtrations de tous ces exemples ſont faictes ci deuant en leurs propoſitions.

1
2 2
7 6
2 8 6 8
4 6 3 2
2 6 4 7 3 9 ⓪①③
3 6 7 6 6 6 (1 3 9 7
2 6 3 3 3 3
2 6 6 6
2 2

ARTICLE II, DES COMPTES DES MESVRES DE TAPISSERIE.

L'AVLNE du meſureur de tapiſſerie, lui ſera 1 ⓪, laquelle il partira (ſur quelque coſté, la ou ne ſont pas les partitions ſelon l'ordonnance de la ville) comme eſt faict ci deſſus de la verge de l'Arpenteur, à ſçauoir en 10 parties egales, deſquelles chaſcune ſera 1 ①, puis chaſque 1 ①, autrefois en dix parties egales, & chaſcune vaudra 1 ②, &c. Quant à leur vſage, veu que lex exemples accordent en tout auec ce qui en eſt dict au premiere Article de l'Arpenterie, elle ſera par icelles aſſez notoire, de ſorte qu'il n'eſt pas meſtier d'en faire ici mention.

ARTICLE III, DES COMPTES SERVANS A LA GAVIERIE ET aux meſures de tous tonneaux.

VNE Ame (qui faict en Anuers 100 pots) ſera 1 ⓪, la meſme ſe diuiſera en profondeur & longueur en 10 parties egales (à ſçauoir egales au reſpect du vin

du vin, non pas de la verge, de laquelle les parties de profondité ſont inegales) & chaſque partie ſera 1 ① contenant 10 potz, puis chaſque 1 ① en 10 parties egales & chaſcune ſera 1 ②, vallant vn pot. Puis chaſque 1 ② en dix parties egales, faiſant chaſcune 1 ③.

Or eſtant ainſi partie la verge, & voulant trouuer le contenu du Tonneau, on multipliera & beſoignera comme au precedent premier article, qui eſtant aſſez manifeſte, nous n'en dirons ici point d'auantage.

Mais veu que ceſte dixieſme partition de la profondeur, n'eſt pas vulgaire, nous en declairerons ceci: Soit la verge A B vne Ame, qui eſt 1 ⓪, diuiſée (ſelon la couſtume) en poincts de profondeur comme ces dix C, D, E, F, G, H, I, K, A, faiſant chaſcune partie 1 ①, leſquelles il faut diuiſer autrefois en 10 en ceſte ſorte: L'on diuiſera premierement chaſque 1 ① en deux, ainſi: L'on tirera la ligne B M, à droictangle ſur A B, & egale à 1 ① B C, puis ſe trouuera (par la 13e propoſition du 6e liure d'Euclide) la ligne moienne proportionelle entre B M, & ſa moitie qui ſoit B N, coupant B O, egale à B N, & ſi N O, fuſt alors egale à B C, l'operation eſt bonne: Puis ſe notera la longueur N C, de B vers A, comme B P, laquelle eſtant egalle à N C, l'operation eſt bonne: Semblablement la longueur D N, depuis B iuſques à Q, & ainſi des autres. Il reſte encore de partir chaſque longueur comme B O, & O C, &c: en cinc, ainſi: L'on trouuera entre B M & ſa dixieſme part, la ligne moienne proportionelle qui ſoit B R, coupant B S, egale à B R; Puis ſe notera la longueur S R, de B vers A, comme B T, & ſemblablement la longueur T R, de B iuſques à V, & ainſi des autres. Et ſemblablement ſe procedera pour diuiſer

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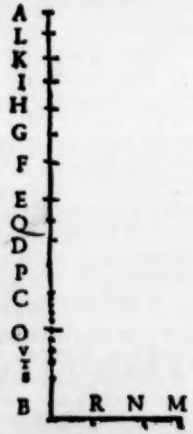
BS, & ST, &c. en ③. Ie di que BS, & ST, & TV, &c. ſont les deſirees ③, ce qui ſe demonſtre ainſi:

Parce que BN eſt ligne moienne proportionelle (par l'hypotheſe) entre BM & ſa moitie; le quarré de BN (par la 17 propoſition du 6e liure d'Euclide) ſera egale au rectangle de BM & ſa moitie, mais icelui rectangle eſt la moitie du quarré de BM, le quarré doncques de BN, eſt egal à la moitie du quarré de BM, mais BO eſt (par l'hypotheſe) egale à BN, & BC à BM, le quarré donc de BO, eſt egal à la moitie du quarré de BC. Et ſemblablement ſe demonſtrera que le quarré de BS, eſt egal à la dixieſme part du quarré BM, parquoi, &c. Nous auons faict la demonſtration briefue, parce que nous n'eſcripuons pas à Apprentifs, mais à Maiſtres.



ARTICLE IIII. DES COMPTES DE LA STEREOMETRIE EN GENERAL.

IL eſt bien vrai que la gaujerie que nous auons declaré ci deuant eſt Stereometrie (ceſt à dire ſcience de meſurer les corps) mais conſiderant les diuerſes partitions

partitions de la verge de l'vn & l'autre, auſſi que ceſtui ci à telle difference de ceſtui la, comme genre à eſpece, ils ſe peuuent diſtinguer par bonne raiſon, car toute Stereometrie n'eſt pas Gaujerie. Pour donc venir à la choſe, le Stereometrien vſera de la meſure de ſa ville, comme vergé ou aulne auec ſes dixieſmes partitions deſcriptes au premier & ſecond article, l'vſage de laquelle (ſemblable à ce qui en eſt dict au precedent) eſt telle: Poſons qu'il y ait à meſurer quelq. colomne quadranguliere rectanguliere, de laquelle la longueur 3 ① 2 ③, l'argeur 2 ① 4 ③, hauteur 2 ⓪ 3 ① 5 ③; La demande eſt combien il y a de matiere. L'on multipliera ſelon la doctrine de la 4e propoſition de ce traicté, longueur par largeur, & leur produict autrefois par hauteur, en ceſte ſorte:

			①	③	
			3	2	
			2	4	
		1	2	8	
		6	4		
		7	6	8	④
		2	3	5	②
		3	8	4	0
	2	3	0	4	
1	5	3	6		
1	8	0	4	8	0
①	②	③	④	⑤	⑥

Et donne produict comme appert 1 ① 3 ③ 4 ④ 8 ⑤.

NOTA. Quelq'un ignorant (car c'eſt à ceſtui la que nous parlons ici) les fondamens de la Stereometrie, pourroit penſer pourquoi l'on dict, que la grandeur de la colomne ci deſſus, n'eſt que de 1 ①, &c. veu qu'elle contient plus que 180 cubes, deſquels la longueur de chaſque coſté eſt de 1 ①; Il ſçaura que le corps d'vne verge n'eſt pas vn corps de 10 ①, comme vne verge en longueur, mais de 1000 ①, en reſpect dequoi 1 ① faict 100 cubes chaſcun de 1 ①; Comme le ſemblable eſt aſſez notoire aux Arpenteurs en ſuper-

en ſuperfice; Car quand on dict 2 verges 3 pieds de terre, cela ne ſ'entend point 2 verges & trois pieds quarrez mais de 2 verges & (comptant 12 pieds pour la verge) 36 pieds quarrez. Pourtant ſi la demande ci deſſus euſt eſté, de combien de cubes chaſcun de 1 ① fut la grandeur de ladicte colomne, l'on accommoderoit la ſolution conforme au requis, conſiderant que chaſque 1 ① de ceux ci, faict 100 ① de ceux la, & chaſque 1 ② de ceux ci, 10 ① de ceux la, &c. Ou autrement ſi la dixieſme part de la verge eſt la plus grande meſure que le Stęometrien ſe propoſe, il la peut nommer 1 ◎, & puis comme deſſus.

ARTICLE V, DES COMPVTATIONS ASTRONOMIQVES.

ANCIENS les anciens Aſtronomes parti le cercle en 360 degrez, ils voioient que les computations Aſtronomiques d'icelles, auec leurs partitions, eſtoient trop labourieuſes, pourtant ils ont parti chaſque degré en certaines parties, & les meſmes autrefois en autant, &c. à fin de pouuoir par ainſi touſiours operer par nombres entiers, en choiſiſſans la ſoixantieſme progreſſion, parce que 60 eſt nombre meſurable par pluſieurs meſures entieres, à ſçauoir 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, mais ſi l'on peut croire l'experience (ce que nous diſons par toute reuerence de la venerable antiquité & eſmeu auec l'vtilité commune) certes la ſoixantieſme progreſſion n'eſtoit pas la plus commode, au moins entre celles qui conſiſtoient potentiellement en la nature, ains la dixieſme qui eſt telle: Nous nommons les 360 degrez auſſi *Commencemens*, les denotans ainſi 360 ◎ & chaſcun degré ou 1 ◎ ſe diuiſera en 10 parties egales, deſquelles chaſcune ſera 1 ①, puis chaſque 1 ① en 10 ②, & ainſi des autres, comme le ſemblable eſt faict par pluſieurs fois ci deuant.

Or eſtant entendue ceſte partition, nous pourrions deſcripre ſelon ce qui à eſté promis, leur facile maniere de Aiouſter, Soubſtraire, Multiplier, & Diuiſer, mais veu qu'elles n'ont aucune difference des quatre propoſitions precedentes, tel recit ne ſeroit que perdre le temps, pourtant nous les laiſſerons ſeruir pour exemples de ceſt article; Y aiouſtant encore ceci; que nous vſerons de ceſte maniere de partition, en toutes les tables & comptes, ſe rencontrans en l'Aſtronomie, que nous eſperons de diuulger, en noſtre vulgaire langue Germanique qui eſt la plus riche, la plus ornée, & la plus parfaicte langue de toutes langues, de la treſexquiſe ſingulierete, de laquelle nous attendons de brief autre demonſtration plus abondante, que Pierre & Iehan en ont faict en la BEWYSCONST ou DIALECTIQVE nagueres diuulguee.

ARTICLE VI, DES COMPTES DES MAISTRES DES MONNOIES, MARchans & de tous eſtats en general.

AFIN de dire en brief & en general, la ſomme & contenu de ceſt article, faut ſçauoir qu'on partira toutes meſures, comme Longue, Humide, Seiche, Argent, &c. par la precedente dixieſme progreſſion & chaſque fameuſe eſpece d'icelles ſe nommera *Commencement*; comme Marc, *Commencement* des pois, par leſquels

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quels ſe poiſe l'or & l'argent ; Liure, *Commencement* des autres pois communs ; Liure de gros en Flandres, Liure Eſterlain en Angleterre, Ducat en Hiſpaigne, &c. *Commencement* de monnoie ; Le plus haut ſigne du marc ſera ④, car 1 ④ peſera enuiron la moitie d'vn Es d'Anuers, la ③ ſuffira pour le plus haut ſigne de la Liure de gros, veu que telle 1 ③ faict moins que le quart d'vn ⑧.

Les ſoubdiuiſions des pois, pour peſer toutes choſes, ſeront (au lieu de demiliure, quart, demiquart, once, demionce, eſterlin, grain, es, &c.) de chaſque ſigne 5, 3, 2, 1, c'eſt à dire, qu'apres la liure ou 1 ⓞ, ſuiuera vn pois de 5 ① (faiſant $\frac{1}{2}$ ℔) puis de 3 ①, puis de 2 ①, puis de 1 ①, & ſemblables ſoubdiuiſions aura auſſi la 1 ① & autres ſuiuans.

Nous eſtimons auſſi vtile, que chaſque ſoubdiuiſion voire de quelle matiere fuſt ſon ſubiect, ſoit nommé *Prime, Seconde, Tierce, &c.* & cela à cauſe qu'il nous eſt notoire, que *Seconde* multipliée par *Tierce* donne produict *Quinte* (parce que 2 & 3 ſont 5 comme il eſt dict ci deſſus) Item que *Tierce*, diuiſee par *Seconde* donne quotient *Prime, &c.* ce qui ne ſe pourroit faire ſi proprement par autres noms ; Mais quant on les veut nommer par diſtinction des matieres (comme l'on dict demie aulne, demie liure, demie pinte, &c.) nous les pouuons nommer Prime de Marc, Seconde de Marc, Seconde de Liure, Seconde d'Aulne, &c.

Mais à fin d'en donner exemple, poſons que 1 marc d'or vaut 36 ℔ 5 ① 3 ③, la demande eſt combien monteront 8 marcs 3 ①. 5 ② 4 ③ : L'on multipliera 3653 par 8154, donne produict par la 3 propoſition qui eſt auſſi la ſolution requiſe, 305 ℔ 1 ① 7 ② 1 ③.

quant

quant aux 6 ④ 2 ⑤, elles ne ſont ici de nulle eſtime.

Poſons autrefois que 2 aulnes 3 ①, couſtent 3 ℔ 2 ① 5 ③. La demande eſt combien couſteront 7 aulnes 5 ① 3 ③ : On multipliera ſelon la couſtume, le dernier terme donné par le ſecond, & le produict ſe diuiſera par le premier, c'eſt à dire, 753 par 325, faict 244725, qui diuiſé par 23, donne quotient & ſolution 10 ℔ 6 ① 4 ③.

Nous pourrions donner autres exemples en toutes les vulgaires regles d'Arithmetique, ſe rencontrans ſouuent es traffiques des hommes ; Comme la regle de Compaignie, d'Intereſt, de Change, &c. demonſtrans comment elles ſe peuuent toutes expedier par nombres entiers, auſſi ceſte facile operation par les getons, mais veu qu'il eſt aſſez notoire par les precedens, nous n'en ferons point de mention.

Nous ſçaurions auſſi demonſtrer plus amplement, par comparaiſon de facheux exemples en rompuz, la grande difference de facilité, qu'il y a de ceux ci à ceux la, mais nous le paſſons outre à cauſe de briefueté.

AV dernier il nous faut encore dire de quelque difference qu'il il y a de ce 6e article, aux 5 articles precedens, c'eſt que chaſcune perſonne peut exercer pour ſoi meſme la dixieſme partinon deſdicts precedens 5 articles, ſans qu'il ſera meſtier d'en eſtre donné par le Magiſtrat quelque ordre general, mais cela pas ainſi en ce dernier, car ſes exemples ſont vulgaires computations, qui ſe rencontrent à chaſque moment, auſquels il ſeroit cõuenable, que la ſolution ainſi trouuée fuſt d'vn chaſcun acceptée pour bonne, & legitime. Pourtant conſiderant ſa treſgrande vtilité, ce ſeroit

roit choſe louable ſi quelcuns, comme ceux qui en attendent la plus grande commodité, ſolicitoient de la faire mettre en effect, à ſçauoir que ioignant les vulgaires partitions qu'il y a maintenant des Meſures, Pois, & Argent (demeurant chaſque capitale meſure, Pois & Argent, en tous lieux immuable) l'on ordonnaſt encore legitimement par les Superieurs, la ſuſdicte dixieſme partition, à fin que chaſcun qui vouldroit la pourroit vſer.

Il auanceroit auſſi la choſe, ſi les valeurs d'argent, principalement de ce qui ſe forge de nouueau, fuſſent valuez ſur quelques *Primes, Secondes, Tierces, &c.*

Mais ſi tout ceci ne fuſt pas mis en œuure, ſi toſt cõme nous le pourrions ſouhaiter, il nous contentera premierement, qu'il ſera du bien à noz ſucceſſeurs, car il eſt certain, que ſi les hommes futurs, ſont de telle nature comme ont eſté les precedens, qu'ils ne ſeront pas touſiours negligens en leur ſi grand auantaige.

Au ſecond, ce n'eſt pas le plus abiect ſçauoir à vn chaſcun en particulier, qu'il lui eſt notoire, comment les hommes ſe peuuent deliurer eux meſmes à toute heure qu'ils vouldroient, de tant & de ſi grans labeurs,

Au dernier, combien que l'effect de ce 6^e^ Article n'apparoiſtra point, peut eſtre, en quelques temps, toutesfois vn chaſcun pourra exercer les cinc precedens, comme il eſt notoire, qu'aucuns des meſmes l'ont deſia mis en œuure.

Fin de l'Appendice.

Huictieſme diſtinction de la Pratique d'Arithmetique qui eſt de nombres incommenſurables appliquez à grandeurs.

TRAICTE DES INCOMMENSVRABLES GRANDEVRS.

Auec vne Appendice de l'explication du Dixieſme liure d'Euclide.

Deſcript par SIMON STEVIN *de Bruges.*

Artificial fertilization of date-palms in Palestine and Arabia

§ 1. — *Plant sexuality*

To the interesting paper of Dr. SARTON in *Isis*, XXI, p. 8-13, I wish to add the following lines :

The Hebrews and Arabs, too, were well acqainted with the process of artificial fructification of date-palms, and clearly expressed it as a kind of plant sexuality. Thus RAB AḤA, a Babylonian Amora of *c.* 400, explains the term *harkabah*, used in the *Mishnah* (1) for the fertilization of the palm trees, as a placing of the flower cluster of the male tree into the flower-vagina of the female tree. The *Zohar* (2) says that the palm tree thrives only through male and female. GERSHON BEN SOLOMON of Arles (3), in his small encyclopaedia *Sha'ar ha Shamayim* (4), informs us that in general there are no males and females among tress. " However ", so he continues, " some people say that among the palm trees there are males and females. The males have the power of impregnating and the females become impregnated through the pollen driven by the wind from the males standing near the females, provided that they stand so near that they can see each other. Similarly, they say of the pistachio tree and the plane tree that they bear fruit only if they have another tree near them. The agriculturists say that all the fruits have males and females, like the apples, quinces and pears. The

(1) *Pesaḥim*, IV, 8, f. 56*a*.

(2) Ed. Wilna, 1894, I, p. 82*a*; cf. also the mystic book *Bahir*, § 59, near the end of the book. The *Zohar*, the Bible of the mystics, was edited c. 1300; see SARTON, *Introduction to the History of Science*, II, p. 878-81.

(3) Died toward the end of the 13th century, and his information is derived from Arabic and Greek sources in Hebrew translation; see SARTON, *Introduction*, II, 886.

(4) In the middle of the third chapter; ed. Warsaw, 1875, p. 23*a*.

long ones, are males and the small and round ones are the females."

BAḤYA BEN ASHER (d. 1340), a mystic and Bible exeget of Spain, says (5): "Not only among palm trees are there male and female, but among all the species of the plants as well as of the minerals there is to be found the division of male and female in a natural way." Sexuality among minerals is also mentioned by SABBATAI DONNOLO (6). This reminds us of the theory of the great Arabic mystic and scientist IBN SĪNĀ (980-1037) (7) that romantic love, *al-'ishq*, "is not peculiar to the human species, but pervades all existing things of the celestial and the elemental and the vegetable and the mineral and the animal, and that its meaning is not perceived nor known, and is rendered more obscure by explanation thereof" (8). A similar idea that sexuality pervades the whole creation was already expressed in the Qurān (9).

The Arabs call the male palm tree *dhikr*, "male," or *nakhal*, and the female tree *'inthaye*, "female," or *nakhla* (10). They also refer to the male tree as to the *faḥl*, "the stallion," and a mat that is made of the woven leaves of the male tree is also known under the name of *faḥl* (11).

§ 2. — *Individual love between palm trees*

Palm growers may have observed that certain date palms thrive better, or thrive only, if fertilized with the pollen of a special tree. Hence the popular belief arose that there are, so to say, romantic love affairs between certain palm trees, or that some

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(5) In his commentary to *Leviticus* 23, 40.

(6) Quoted by M. STEINSCHNEIDER, *Hebraeische Uebersetzungen*, p. 850, note 34. DONNOLO lived 913 till after 982; see SARTON, *Introduction*, I, 682.

(7) See SARTON, *Introduction*, I, 709-713.

(8) Quoted from his special treatise on *Al-'Ishq*, "Love," by LANE, *Arabic-English Lexicon*, p. 2054*b*.

(9) Sûra 36, 36. Cf. A. SPRENGER, *Das Leben und die Lehre des Mohammad*, I, p. 61, note.

(10) Cf. IM. LOEW, *Die Flora der Juden*, II, p. 316, 318.

(11) See hereafter § 2, and LANE, *Arabic-English Lexicon*, p. 2346*b*. For more literature on the subject of sexuality of the palms and plants see S. KRAUSS, *Talmudische Archaeologie*, II, p. 209, 592; M. STEINSCHNEIDER, *Hebraeische Uebersetzungen*, p. 850, note 34; and particularly LOEW, *Flora der Juden*, II, 318. The latter passage was kindly called to my attention by PROFESSOR L. GINZBERG.

palm trees fall in love with individual male trees and refuse to accept the pollen of other trees. To the verse (12) " The righteous shall flourish like the palm tree " there is an old homily in the *Midrash* (13) which reads as follows : " Even as the palm tree falls in love, so the righteous ones fall in love. The object of the love of the righteous man is God. RABBI TANḤŪMĀ (14) tells the following story : There was once a palm tree in Amathus which did not bear fruit, though it was fertilized. A palm-gardener passed by, looked at it and said : This palm tree is looking toward Jericho and is lovesick for a palm tree from there. So they went and fertilized it with the pollen of this tree, and it bore fruit."

M. GRUENBAUM (15) quotes a parallel story from the Arabic geographer QAZWĪNĪ (16) (1203-1283). A palm tree which used to bear fruit regularly, ceased to do so for two years. An expert, a kind of tree-doctor, was consulted, and he, after examining the tree, said : There is nothing the matter with her, but she is lovesick for another male tree. Then he found out the other male tree in the neighborhood and said : " *hiyya 'āshiqa lidhālika-l-faḥl*," she is in love with that stallion." She was fertilized with the pollen of this tree and bore fruit (17).

§ 3. — *The palm-gardeners of Jericho*

To the story of the palm tree in Amathus which was longing for the palm tree in Jericho, it should be remarked that Jericho

(12) *Psalms* 92, 13.

(13) *Genesis Rabbah*, XL, ed. THEODOR, Berlin 1903, p. 387; *Midrash Tehillim*, XLII, quoted by THEODOR, *ib.*; Yalqūṭ II, § 845. The above translation follows the combined text of *Gen. Rabbah* and *Midrash Tehillim*.

(14) A Palestinian Amora of the fourth century.

(15) In *Zeitschrift der Deutschen Morgenlaendischen Gesellschaft*, vol. 31, 1877, p. 330 f.; and in his book *Gesammelte Aufsaetze zur Sprach- und Sagenkunde*, Berlin 1901, p. 202.

(16) I, 269, Cited also by DE SACY, *Chrestomathie arabe*, III, 481. On QAZWĪNĪ see SARTON, *Introduction*, II, 868-70.

(17) The Hebrew word *ta'awah*, used in the *Midrash*, means, like the Arabic *'ishq*, " lovesickness." Etymologically, the Arabic *'ashiqa* corresponds to the Hebrew *ḥashaq*, *Gen.* 34, 8, which GENESIUS, in the *Hebrew Lexicon*, failed to mention.

was famous for its noble palm trees and called the city of the palm trees. An old *Mishnah* (18) of before 150 A.D. tells us that the people of Jericho used to work with the fertilization of the palm trees during the whole day of the 14th of Nissan, the eve of the Easter festival, though this day was a legal holiday at which work was prohibited, and that the Rabbis did not protest against this violation of the law. The reason for this indulgence of the Rabbis is given by NATHAN BEN YEHIEL (19) (1035-1106), the Italian lexicographer of the Talmud, namely, that once the right time for fertilization has come, a delay will render the operation futile. Hence it seems that in Jericho the season for fertilization was in the first half of Nissan (April).

§ 4. — *The process of fertilization*

RABBI NATHAN quotes an old gloss, apparently coming from the commentaries of the Gaonim in Babylonia, which reads as follows (20) : " God created the palm trees as male and female, and the one cannot thrive without the other one. How is the procedure ? When the time of the maturity of the female tree arrives, and it spreads its inflorescences with the dates which are still small like peas, then one fetches the male flower clusters, inserts their stalks into the spathe of the female tree and ties them to the same and scatters the pollen over them. The female inflorescence will then thrive and bring forth good fruit. However, one must be careful not to delay the fecundation even one day lest the fruit be spoiled." LOEW (21) compares the description given by the German naturalist OKEN (1779-1851), which reads in German : " Ende Hornungs (February) nimmt man die geschlossenen Scheiden der Staubbaeume ab, schneidet sie auf, nimmt die Rispen, deren Blueten noch geschlossen sind, heraus. Dann schneidet man je zwei Ruten, welche eine Gabel bilden, ab und bewahrt sie bis in den Maerz auf, wo die weiblichen

(18) *Pesaḥīm* IV, 8; cf. also *Tosephta, ib.*, II, 19, and *Babli* 56*a*.

(19) See SARTON, *Introduction*, I, 782. Unfortunately, the name there and in the Index was disfigured, by a misprint, into B. JELIEL,

(20) *Aruch Completum*, V, 354.

(21) *Flora der Juden*, II, 335.

Scheiden beim Druck eine Art Geraeusch hoeren lassen. Dann oeffnet man sie ein wenig und legt die Ruten hinein, denn sind die Scheiden schon lange geoeffnet, so verfliegt der Staub zu schnell." LANE (22) quotes from the *Lisān-al-'Arab* the following description : " You leave the spathe of the female palm tree two or three nights after its bursting open : then you take the stalk of a raceme of the male tree, which is best if old, of the preceding year, and insert it into the spadix of the female, after shaking off the pollen, as above mentioned; and this you do according to a certain measure : it should not be done but by a man acquainted with the manner of proceeding in this case; for if he be ignorant, and do too much, he turns the spathe, and mars it; and if he do too little, many of the dates produced will be without stones; and if he do it not at all to the palm tree, he will derive no advantage from the spadix thereof that year."

§ 5. — *Terminology*

The Hebrew technical term used for this process of fertilization is *harkabah*, a term which is regularly and much more often employed for grafting and inoculation. This confused the modern Hebrew dictionaries to the Talmud (23), and also other authors (24) who failed to recognize this new meaning of the term. The new, and rather rare, meaning was, however, well known to the Babylonian Amora RAB AḤA, the Babylonian Gaonim and RABBI NATHAN B. YEHIEL (25). The Arabic term is *talqīh* or *'ilqāḥ*, originally meaning : " the stallion-camel impregnated the she-camel."

§ 6. — *The Babylonian palm trees*

The Palestinian Talmud (26) refers in a certain passage (27)

(22) *Arabic-English Lexicon*, p. 2668*b*, under *laqiḥa*.
(23) I looked up BEN IEHUDA, LEVY, JASTROW and KOHUT.
(24) Quoted by LOEW, *loc. cit.*, p. 318.
(25) See above §§ 1 and 4.
(26) Final edition *c.* 425; see SARTON, *Introduction*, I, 401.
(27) *Yebamot* XV, 15*a*, 16; *Ketubbot* IV, 29*a* 48.

to "those palm trees in Babylonia which are not in need of fertilization." From this passage KRAUSS (28) and LOEW (29) draw the conclusion that Babylonian palm trees *in general* did not require fertilization. Now we gather from all the other sources that artificial fertilization was well known and commonly practiced in Babylonia. The bas-reliefs of King ASHUR-NASIR-PAL (885-860 B.C.) represent, and HERODOTUS (I, chap. 193) describes, the process of fecundation of palm trees in Babylonia (30). The Babylonian Amora RAB AḤA and the Babylonian Gaonim, as we have seen above, are well familiar with the procedure. I, therefore, prefer to interpret the passage as meaning "such trees" and as alluding to a certain species of palm trees which did not need fecundation, or which, like the *jechriq* (31), dit not thrive when fecundated. This is also clearly the conception of the commentary *Qorban 'Edah*.

New York City. SOLOMON GANDZ.

(28) *Talmudische Archaeologie* II, 209.
(29) *Loc. cit.*, p. 314.
(30) Cf. SARTON's paper in *Isis* XXI, p. 8-13.
(31) See LOEW, *ib.*, p. 318.

Additional note on date culture in ancient Babylonia

Since the publication of my paper on The artificial fertilization of date-palms in the time of ASHUR-NASIR-PAL, B.C. 885-60 (*Isis* 21, 8-13, 4 pl., 1934), Professor CONWAY ZIRKLE of the University of Pennsylvania, has brought to my attention two important memoirs bearing on the subject.

The former is by V. SCHEIL : De l'exploitation des dattiers dans l'ancienne Babylonie (*Revue d'assyriologie*, 10, 1-9, 1913), wherein evidence is given that date culture was already very elaborate in Babylonia, c. 2400 B.C. (that is more than fifteen centuries before the time of ASHUR-NASIR-PAL), and that some empirical knowledge of date sexuality and fertilization was then already available.

Says Father SCHEIL (p. 1) :

" Sans aucun doute, les Babyloniens, ne le cédant en rien à cet égard aux Égyptiens et aux Arabes, avaient défini et dénommé avec amour jusqu'aux moindres particularités de cet arbre par excellence. Eux aussi possédaient des noms spéciaux pour le dattier, le dattier femelle, la datte verte, la pâte de dattes, l'inflorescence du dattier avant la formation des fruits, les spadices ou ensemble de fleurs, les régimes de dattes, les spathes ou enveloppes des spadices, les moignons qui restent des frondes tombées, la nervure médiane de la fronde, les filaments de la base des frondes, la fronde ou palme, la feuille de la palme. Il s'en faut cependant que dans nos tablettes cette terminologie soit complète; les fragments de contrats et de vocabulaires qui s'y réfèrent ont d'ailleurs été peu étudiés."

His study is devoted mainly to the publication of a new text—a document of Yokha-Umma, written in the fifth year of the reign of GIMIL SIN, and he refers to another document of about the same time (two years later) published by MYHRMAN (*Babyl. Exped.*, III, 1, p. 63). These two documents prove :

" 1. That there existed as early as 2400 B.C. in the Tigris-Euphrates Delta large date-palm orchards of many hectares in extent; 2. That the size of orchards

was readily estimated, not by the usual field measurements, but by the number of trees in it; 3. That artificial fecundation of the female date tree was employed, and that male trees were grown apart; 4. That the estimation of the produce was made according to series of trees of practically equal bearing ability, and instead of weight, volume measure was employed; 5. That the maximum yield per tree went as high as 300 qa (105 kilograms, or 141 liters); 6. That accounts in this matter were kept with rigor and preciseness, according to the most rational proceedings."

Instead of quoting Father SCHEIL's conclusions in the original, I have given them in the English translation included in the second paper, by A. H. PRUESSNER: Date culture in ancient Babylonia (*The American journal of Semitic languages*, vol. 36, 213-30, 1920). According to PRUESSNER, two articles of HAMMURABI's famous code (c. 1955-1913 B.C.), refer to the artificial fertilization. These articles are §§ 64-5, which he proposes to translate as follows (p. 226):

"§ 64: If a man entrust his date grove to a shakînum for pollinating, the shakînum shall give of its produce, for the time that he holds the orchard, two-thirds to the owner of the orchard; one-third he himself shall take. § 65: If the shakînum does not pollinate the orchard and thereby diminish the produce, he shall pay rent on the basis of the adjacent orchards."

(Compare with HARPER's translation, *Code of* HAMMURABI, p. 33, where there is no reference to pollination). He sees another reference to pollination in another legal document,—R 23, transl. by SCHORR: *Altbabylonische Rechtsurkunden*, p. 189.

I have no means of appreciating whether PRUESSNER's interpretation is correct or not, as I am not an Assyriologist, but it is plausible.

The documents explained by Father SCHEIL, proving the high antiquity of the artificial fertilization of date-palms in Babylonia, increase the plausibility of the sexual interpretation of ASHURNASIR-PAL's bas-reliefs.

GEORGE SARTON.

Notes and Correspondence

Answer to Query no. 22. (*Isis* 19, 503).—" Wind-blowers."—These symbolic figures, human heads representing the winds, are far older than the " maps of several centuries ago." They date back at least to the third century A.D. since four such heads are to be found carved round about the zodiac in a scene of the birth of the god Mithra. The carving is on an altar-stone from Altbach near Treves, that extraordinary site where since 1924 over 50 temples and chapels dating back to Roman times have been discovered. The carving in question is reproduced with comments in *Natur und Kultur*, 1934 (August) p. 325, after the report of the excavations " *Die Erforschung des Tempelbezirks im Altbachtale zu Trier*," by Dr. Siegfried Loeschke. Similar " wind-blowers " doubtless figure in the four corners of the Mithraic monument from Heddernheim, now in the Wiesbaden Museum; cf. Fr. Koepp, *Die Römer in Deutschland*, 1905, fig. 135 (*Monographien zur Weltgeschichte*, vol. XXII, Verlag Velhagen und Klasing, Bielefeld & Leipzig). Hence these emblems for the winds may well be late Persian.

Such wind-blowers also figure on mosaic floors of the byzantine period (about the 5th century) at least in Palestine.

An example has been found in Beisan, more or less in connection with a symbolic representation of the twelve months. It would not be surprising to find similar heads also in Italy, or at any rate in North African mozaics.

(Jerusalem.) Hugh Bévenot.

Discovery of the anesthetic properties of cocaine, (1884).—It is appropriate, I think, to call attention to the fact that this year marks the fiftieth anniversary of an important event in the history of medicine from which scarcely a person now living in a civilized community has not greatly benefited. This was the discovery by Dr. Carl Koller in 1884 of the local anesthetic properties of cocaine, a discovery which inaugurated the brilliant investigations in the chemistry and pharmacology of local anesthesia which have culminated in the exceptional facilities and technique now available in this field.

The circumstances leading to this discovery are of interest. The

following account is quoted in part from a report in the *Scientific Monthly* (20:304, 1925):

The aboriginal Incas of the highlands of South America seem to have been acquainted with the anesthetic properties of extracts of coca leaves. Dr. MOODIE has suggested that the extraordinary trephining so frequently found among Incan skulls may have been accomplished, insofar as pain relief was concerned, by the operator chewing a cud of coca leaves, the juice of which could be dropped upon the wound when the pain became severe.

"The steps in the introduction of cocaine as a local anesthetic were many. ALEXANDER WOOD, in 1853, introduced the hypodermic syringe, without which the administration of cocaine or its derivatives would be difficult. ALBERT NIEMANN, in 1858, isolated cocaine from coca leaves, while working in the laboratory of FRIEDRICH WOEHLER, and both NIEMANN and WOEHLER described the numbing effect of the alkaloid upon the tongue, without recognizing the significance of this fact. Cocaine remained a curiosity for many years. In 1880 a British medical commission learnedly reported that the substance had no medical value, being at best merely a poor substitute for caffein. This same year, VON ANREP published a careful pharmacological study of the alkaloid, in which the local anesthetic properties were hinted at, but it remained for Dr. CARL KOLLER actually to demonstrate its great value.

"Due, perhaps, to his own charming modesty, Dr. KOLLER has not generally received the full credit that he deserves for his demonstration of the local anesthetic properties of cocaine. It may be of interest to give such facts in the matter as are available. CARL KOLLER was born in Schuettenhafen, Bohemia, on December 3, 1857. He graduated from the University of Vienna in 1882 and interned at the Allgemeines Krankenhaus. From 1885 to 1887 he was assistant to SNELLEN and DONDERS at Utrecht, Holland, and then came to New York City in May, 1888. He has since continued most successfully (a fact to which I may personally testify) in the practice of ophthalmology in New York. Dr. EMIL MAYER, chairman of the Committee on Local Anesthesia for the American Medical Association, in a report published in the *Journal of the American Medical Association* in 1920, presents Dr. KOLLER's story of his discovery of the local anesthetic powers of cocaine."

In 1884 KOLLER was a senior intern at the Allgemeines Krankenhaus in Vienna under Professor SIGMUND FREUD, the great psychiatrist. Dr. FREUD had as a patient the noted German physiologist, BRÜCKE, who had become addicted to morphine as a result of an injury to a thumb. Dr. FREUD quite logically considered the proposition of substituting a central nervous system stimulating drug, such as cocaine was known

to be, for the central nervous system depressant drug, morphine, to which the patient was addicted. Before attempting such a substitution, however, Dr. FREUD, with great wisdom, proposed to Dr. KOLLER that he should study carefully the physiological effects of cocaine when taken internally. As is the case with many students, Dr. KOLLER was not particularly interested in his master's problem. He desired to find some means for achieving local anesthesia in connection with eye surgery. At that time, the only satisfactory method for local anesthesia was RICHARDSON's ether spray which was not suitable for eye work. In undertaking the study of cocaine, Dr. KOLLER noted its benumbing effect on the tongue, as had other workers with the drug since its discovery. " It occurred to KOLLER, however, that here might be the agent for which he was seeking in connection with eye anesthesia. Experiments in STRICKLER's laboratory in Vienna on animals and normal humans convinced him of the importance of his finding, and he made his first report to the German Ophthalmological Society at Heidelberg on September 15, 1884, through the agency of Dr. BRETTAUER of Trieste. Later, he published a paper on the subject in the *Wiener Medizinische Wochenschrift* (October 25, 1884), which was immediately translated into important medical publications abroad, and within a year the new procedure was in use all over the world." In fact, so quickly did the importance of the discovery become common knowledge that in 1885 Dr. JAMES L. CORNING, of New York, and Drs. HALSTED and CUSHING of Baltimore, had already demonstrated hypodermic and spinal anesthesia with the use of cocaine solutions.

" Recent progress in the exact knowledge of local anesthetics, together with the scientific study of their toxicity and therapeutic values, has been greatly facilitated by the appointment of committees for their appraisal in both England and the United States. The field has proven a fertile one for the synthesis of chemical relatives of cocaine, and scarcely a year has passed since KOLLER's discovery without the announcement of a new local anesthetic agent. The most valuable method of inducing local anesthesia, through infiltration, was introduced by C. L. SCHLEICH in 1894, while the most satisfactory and least toxic of all the substitutes for cocaine was introduced by the chemist ALFRED EINHORN, and the clinician, Dr. H. BRAUN, in Germany," as " novocaine " (procaine U.S.P.) in 1905. " BRAUN also introduced the use of epinephrin with local anesthetic agents in order to delay absorption and check bleeding."

The establishment of the chemical constitution of cocaine by RICHARD WILLSTAETTER made possible the work of EINHORN and of many later investigators by indicating the chemical portions of the molecule responsible for local anesthetic action. The way was now open to develop

new compounds of low toxicity and of powerful local anesthetic effectiveness. One of the most interesting recent developments in this field has been the study of G. A. ALLES and P. K. KNOEFEL (*Archives Internationales de Pharmacodynamie et de Thérapie*, 47:96, 1934) of local anesthetics with vasopressor activity. Compounds of this type make it unnecessary to add epinephrine to the local anesthetic solution for the purpose of constricting the blood vessels, thus delaying absorption, prolonging local action, and reducing systematic toxicity.

Dr. KOLLER has appropriately been honored on this, the fiftieth year of his interesting discovery, by special programs arranged for him by the American Association for the History of Medicine meeting at Cleveland in June, and by the American Academy of Ophthalmology and Otolaryngology meeting at Chicago in September. More than anyone now living is Dr. KOLLER responsible for the effective relief of physical pain and suffering. It would only seem decent that mankind would this year offer some appropriate honor to him.

CHAUNCEY D. LEAKE.

On the bone of the stag's heart.—The following extract from the first book of the *Novo receptario* (Florence, 1498), the first modern pharmacopoeia, may serve as a footnote to Dr. M. C. WELBORN's paper on " The errors of the doctors according to ROGER BACON " (*Isis* 18, 26-62, 1932, p. 58).

Dell Osso di Quore di Cerbio

Osso di quore di cerbio e / una certe chartilagine dura con uno poche di charne del quore del cerbio. No sipuo sophisticare / cioe in nel coporlo : ma bene e / uero che siunde assai cose dure p quello. El uero osso e / che noe di molta grandeza / e / in forma triangolare / intormo a quello sempre uiresta im pocho di charne / perche nello spic charlo nosi puo torlo sepre netto.

(Madison, Wisc.) EDWARD KREMERS.

Émile Maupas (1842-1916). — Je détache des très intéressants souvenirs que publie M. LOUIS BERTRAND dans la *Revue des deux mondes* sous le titre « L'Alger que j'ai connu » (15 juillet, 1934, p. 331) les notes suivantes concernant EMILE MAUPAS, l'une des maîtres de la protozoologie (voir *Isis* 14, 417).

« Plus intime et plus propice aux délicats entretiens était la bibliothèque de la rue de l'État-major, l'ancien palais de MUSTAPHA PACHA, avec son beau patio et ses galeries en arcades. On n'y travaillait guère, on y potinait ferme. Mais on y voyait défiler toute une variété de types algérois, des clients de toute catégorie, depuis le lycéen paresseux qui venait copier clandestinement sa version latine

jusqu'aux sommités de l'armée, du clergé, et de la magistrature. Tout ce monde était reçu avec une affabilité, une patience et une complaisance admirables, par le conservateur de ce temps-là, l'éminent biologiste, EMILE MAUPAS, qui a laissé, paraît-il, une œuvre géniale et qui, profondément inconnu de la plupart des Algériens, était célèbre dans les milieux savants du monde entier.

Cet homme d'un si rare mérite était d'une incroyable modestie. Jamais une allusion à ses travaux, du moins en dehors d'un petit cercle d'amis : il ne voulait être, pendant les heures qu'il devait à l'État, que le serviteur du public. Tout le reste de son temps appartenait à ses ' petites bêtes ', comme il disait. Cette passion pour les microbes était, en vérité, bien surprenante, chez cet ancien chartiste que sa formation professionnelle destinait plutôt aux études d'histoire et aux fouilles d'archives. Il y fallut la vocation et ce qui s'appelle proprement le feu sacré. Il dut faire lui-même son éducation scientifique, loin de tout centre universitaire, avec une bibliothèque mal outillée. Il nous contait que, le jour où, à force d'économies, il avait pu s'acheter un microscope pour ses observations, il avait éprouvé la plus grande joie de sa vie. Ses fonctions lui laissant toutes ses matinées libres, il était debout dès l'aube, aux aguets devant ses bouillons de culture, sur la terrasse d'une modeste maison d'ouvriers, qu'il habitait, à Bab-el-Oued, en bordure de la mer, et où il est mort. C'était le pauvre de la science, n'attendant rien d'elle, ni honneurs, ni fortune, ni même la notoriété, uniquement satisfait par les joies de la connaissance et de la découverte. Ce Normand de Falaise vivait là, sur sa terrasse de Bab-el-Oued, au milieu de tous les prestiges de la lumière et de la couleur, sans en jouir, ni en rien voir, exactement comme il eût vécu dans un poêle de Hollande, ou dans un grenier de Koenigsberg."

EMILE MAUPAS est encore bien mal connu non seulement en Algérie, mais même en France. Sa biographie ne se trouve ni dans la « Grande Encyclopédie », ni même dans le « Larousse du XX^e^ siècle » ! G. S.

Program of the History of Science Dinner Club, University of California, Berkeley, California, for the academic year, 1933-1934.

After a call for the organization of the club sent out by the undersigned on September 5, 1933, an organization meeting was held on September 12. The following program was carried through during the academic year.

October 10, 1933—V. F. LENZEN—The evolution of physical thought. November 14, 1933—W. C. BLASDALE—The development of chemistry with special reference to the concept of the atom. December 12, 1933—C. A. KOFOID—The development of the biological sciences. January 16, 1934—D. C. DUNCAN—An account of mathematical problems famous in the history of mathematics. February 13, 1934,—A. PABST—A sketch of the development of crystallography. March 13, 1934—E. C. VAN DYKE—The history of scientific exploration in the North Pacific Ocean and the land areas adjacent thereto. April 10, 1934—J. W. THOMPSON—Interrelation of science and history. May 8, 1934—W. F. MEYER—Some phases of the history of astronomy. HERBERT M. EVANS.

Berkeley meeting of the American Association for the Advancement of Science (June 1934). Section of historical and philological sciences and History of Science Society.

Sections L and N (Medical Sciences) held a joint session on the morning of June 22. A symposium on the Hearst Medical Papyrus, which was exhibited in the University of California Library, was given under the chairmanship of Professor C. D. LEAKE. Professors A. L. KROEBER and E. W. GIFFORD, of the University of California, gave a physical description and discussed the methods of preservation of the papyrus. Dr. H. F. LUTZ, of the University of California, discussed the philological position of the papyrus and its significance in the introduction of Egyptian sciences. Dr. S. V. LARKEY, of the University of California Medical School, discussed the relation of the Hearst Medical Papyrus to other medical papyri and its position in the history of medicine. Following this symposium Dr. A. W. MEYER, Stanford University, presented an illustrated paper on HARVEY's " de Generatione " (1651).

In the afternoon Section L combined with the History of Science Society and the Linguistic Society of America in a joint program, under the chairmanship of Professor C. D. LEAKE, vice-president of the History of Science Society. Dr. F. E. BRASCH, of the Library of Congress, was in attendance at the meeting. Professor JAMES WESTFALL THOMPSON, of the University of California, discussed " The Influence of Science in the Nineteenth Century on the Writing of History." Professor OLAF LARSELL, of the University of Oregon, gave an illustrated biographical sketch of BERZELIUS. Professor C. A. KOFOID, of the University of California, discussed the question, " To What Extent Did WILLIAM CHARLES WELLS Anticipate the Ideas of CHARLES DARWIN on Natural Selection?" THOMAS COWLES, of the University of California, offered a paper on " MALTHUS, DARWIN, and BAGEHOT : A Study in the Transference of a Concept." F. R. JOHNSON, of the Johns Hopkins University, discussed " The Relation of THOMAS DIGGES to Astronomy in Sixteenth Century England." Dr. ELMER BELT, of Los Angeles, spoke on " The Influence of EDISON's Cold Electric Lamp on the Progress of Urology." PEVERIL MEIGS III, of Chico, presented a paper on " The Scientific Observations of the Dominican Missions of Lower California." The last part of the program was devoted to a symposium on linguistics in which the following papers were offered : " The Speech Consciousness of the Ancient Near Eastern Peoples and Its Significance in the History of Culture," by Professor H. F. LUTZ, of the University of California; " Analysis and Synthesis and the Use of Greek Words in Natural Knowledge," by Professor W. E. RITTER, of the University

of California; and "Every-day Figures of Speech," by Professor W. H. DAVIS, of Stanford University.

In connection with the joint meeting of Section L and the History of Science Society, Professors HERBERT MCLEAN EVANS and JAMES WESTFALL THOMPSON, with the assistance of Mr. and Mrs. THOMAS COWLES, arranged an exhibit of first editions of epochal achievements in the history of science which was displayed at the University of California Library. Professor EVANS prepared a special check list of the volumes shown in the exhibit, copies of which may be obtained from the University of California Press for thirty-five cents. CHAUNCEY D. LEAKE.

Personalia.—Miss ELIZABETH HELEN ALEXANDER, the distinguished Scotch sculptress and scholar, bibliographer, and contributor to *Isis*, was awarded the honorary degree of doctor of laws (LL.D.) by the Senate of the University of Glasgow on June 20, 1934.

Dr. GEORGE SARTON was elected an honorary member of the American Association of the History of Medicine at its annual meeting in Cleveland on June 11, 1934.

Reviews

Werner Jaeger. — ARISTOTLE. *Fundamentals of the History of his Development*. Translated with the author's corrections and additions by RICHARD ROBINSON. VII+410 pp., (Oxford, The Clarendon Press.). 1934. Price $ 6.00.

Professor JAEGER's *Aristotle* was published eleven years ago. It has done much to modify the view that ARISTOTLE was uncompromisingly opposed to PLATO and also the view that his extant writings present a homogeneous system in which nothing is contradicted and nothing is superseded. This analysis of ARISTOTLE's writings shows how he developed gradually, especially in physics, ethics, and politics. ARISTOTLE was also the compelling organiser of reality and of science. He bequeathed to Hellenistic science a complete devotion to the objectivity of the world which flowered later in the Alexandrian school. He was not an encyclopedist. The astounding totality of ARISTOTELIAN sciences is an organic growth from the central point of his philosophy, the notion of form. As he developed, his " form " changed from a theoretical conception of being to an instrument to be applied to science, a morphological and phenomenological study of all things. His philosophy possessed the power of creating sciences, so that new ones were always springing forth, such as the biological, morphological and physiological study of nature, or the biographical and morphological sciences of culture. The chapter on the organization of research analyses ARISTOTLE's activities during his second stay in Athens. This was the period of his maturity and also of his greatest scientific activity. In this period his antiquarian researches were made which were fundamental for the history of Greek literature and the chronology of the classical theatre, the collection of 158 constitutions was assembled, and his works *On the Heavens*, on the *History of Animals*, and the books on the *Parts* and on the *Generation of Animals*, on *Physics*, and on *Coming-to-be* and *Passing Away* were written. In all these he foreshadowed the science of future millenia. He used the method of applying the principle of form to the details of reality, and thus brought forth the idea of the uniformity of nature. It is not the effort of the writer of this analytical treatise to work out a chronology of ARISTOTLE's writings but rather to show how his philo-

sophical ideas formed the basis for his maturer work in the Academy. It was in this period that his scientific ideas took form so effectively as to profoundly influence the course of scientific development even to the present day.

July 12, 1934. CHARLES A. KOFOID.

Robert T. Gunter.—*The Greek herbal of* DIOSCORIDES, *illustrated by a Byzantine A.D.* 512, Englished by JOHN GOODYER A.D. 1655, edited and first printed A.D. 1933. XII+701 p., 396 ills. in text. Oxford, Printed by JOHN JOHNSON for the author at The University Press, 1934. Price £3 3s.

No English translation of this great work compiled by DIOSCORIDES in the first century A.D. has hitherto been published, although it has been the chief source from which the herbalists of all nations have drawn their inspiration and not a little of their information. The present publication is a literal transcription, and in some pages a reproduction by the Replika process, of the text of JOHN GOODYER, the Petersfield botanist who in 1652 to 1655 wrote out on 4540 quarto pages the Greek text with an interlinear English translation. Unfortunately, because of the lack of some wealthy patron, the translation was never published. To what extent the Elizabethan and Jacobean herbalists, such as GERARD, PARKINSON, and others, utilized this translation is not indicated by the editor. His manuscript, with his fine botanical library, went to Magdalen College, where it remained " unnoticed and unused by generations of classical tutors who, in lectures on the classics, have preached the sterile joys of reading dead languages in the original, rather than the duty of making the contained information available to their fellow-countrymen."

The text remains unchanged, except for needful punctuation and a few changes in the order of words to clarify the meaning. The original spelling is not even unified, and the atmosphere of the original style of this valuable historical document is thus preserved.

The illustrations are the work of a Byzantine artist of about A.D. 512 for presentation to JULIANA ANICIA, daughter of ANICIUS OLYBRIUS, Emperor of the West in 472 A.D. The editor states that there is good internal evidence that the artist based his drawings upon originals not far removed from sketches by the famous botanist CRATEUAS, the father of plant illustration, whose descriptions of plants are occasionally quoted in the text of DIOSCORIDES. The best of these Anician drawings are the ones associated with the explanatory text containing quotations from CRATEUAS. Specific identification of these illustrations is fairly certain in some instances, but doubtful in many. The identifications made

by DAUBENY (1857) in his *Roman Husbandry* are reprinted as an appendix, and SARACEN's (1598) Latin index is reproduced.

The book falls into five chapters, (1) aromatics, oils, ointments, and trees; (2) living creatures, milk and dairy produce, cereals and sharp herbs; (3) roots, juices, and herbs; (4) herbs and roots; and (5) vines and wines, metallic ores. The contents form a numbered catalogue, but the arrangement and sequence do not constitute a system. The account of each item follows somewhat the following order: (1) the name or names of the plant or substance and its local sources; (2) sometimes, but not always, some structural characteristic of the plant and its several sorts or appearances; (3) an account of its various methods of preparation and statements of its various uses; and (4) precautions to be observed in its preparation and preservation.

To the critical reader of today the text reveals the pressure of tradition, the potency of superstition, and a blind belief in the universal utility in the products of nature. It is also suggestive of wide, though quite empirical, testing of and search for, the uses of things, and shows some evidences of profit by experience.

The evidences of acuity of observation are slight, except for the work of the artist in some instances, and critical comparison is even less apparent. Even in matters where health and life were at stake mankind two milleniums ago had not progressed very far along the road of scientific observation, experiment, and conclusion.

July 20, 1934. CHARLES A. KOFOID.

P. Ch. Sengupta.—*The Khaṇḍakhādyaka, an astronomical treatise of* BRAHMAGUPTA. Translated into English with an introduction, notes, illustrations and appendices. xxx+204 p. The University of Calcutta, 1934.

The earliest Hindu scientific works dealing with astronomy are the so-called *Siddhāntas*, of which there are five various recensions, versions or editions. In their main astronomical doctrines they show Greek influence, but the unknown author has tried to preserve as much of the old Hindu astronomical lore as was possible without gross inconsistency. So far the report of SARTON (1), who places them tentatively in the beginning of the fifth century, so that they would antedate the work of ĀRYABHAṬA (born 476) with about a century. SENGUPTA, however, the author of the present book, believes he has established that the scientific Hindu astronomy was created by ĀRYABHAṬA, whom he designates as the father of Indian epicyclic astronomy. According to SENGUPTA (2)

(1) *Introduction to the History of Science*, I, p. 386 f.

(2) See Appendix III, p. 194.

the *Siddhāntas* represent the foreign systems of astronomy that had come to India before ĀRYABHAṬA's time. The *Romaka Siddhānta* transmitted Greek theories, while the Pauliśa Siddhānta was probably of Babylonian origin.

BRAHMAGUPTA (born 598), who was in his youth a bitter opponent of ĀRYABHAṬA, was nonetheless compelled to follow his system when he wrote about astronomy. Yet the *Khaṇḍakhādyaka* is not simply an abridgment of ĀRYABHAṬA's treatise, but it contains also several corrections and original contributions. The *Khaṇḍakhādyaka* was composed about 665 in the form of a *Karana*, i.e. a practical handbook for students of astronomy and almanacmakers. The book consists of ten chapters. The first eight deal with I *Tithis*, *Nakṣatras* (Hindu zodiacal constellations) etc.; II The true and mean places of star-planets; III The three problems relating to diurnal motion; IV The lunar eclipses; V The solar eclipses; VI The rising and setting of planets; VII The position of the moon's cusps; VIII The conjunction of planets. The last two chapters, IX and X, are the so-called *Uttara Khaṇḍakhādyaka*, which contains supplementary matter. A comparison with the contents of the *Sūrya Siddhānta* (3) will show that they deal essentially with the same subject.

It was at the court of AL-MANSUR (754-75) that Arabian scholars met the Hindu scientist KANKAH, from whom they learned Hindu astronomy in BRAHMAGUPTA's treatises. BRAHMAGUPTA taught the Arabs astronomy before they became acquainted with PTOLEMY. The famous *Sindhind* of Arabian literature is a translation of BRAHMAGUPTA's *Brahmasiddhānta;* and the only other book on Hindu astronomy, called *Alarkand*, which they knew, was a translation of his *Khaṇḍakhādyaka* (4). Professor SENGUPTA gives us the English translation as Part I of a complete edition of the *Khaṇḍakhādyaka*, and promises that in due time the second part, containing the Sanscrit text will also be published. The students of Hindu and Arabic astronomy will be under great obligation to SENGUPTA for his translation and for his learned notes and appendices. The determination of the Hindu factor in the history of science is extremely difficult because of the lack of good critical editions, of reliable translations and of a definite chronology. The edition of the *Khaṇḍakhādyaka* will throw more light on a dark period in the history of astronomy.

SALOMON GANDZ.

(3) Quoted also by SARTON, *Introduction*, I, p. 388.
(4) See E. SACHAU, *Alberūnī's India*, II, p. 304.

Louis Roule.—BUFFON *et la description de la nature.* 248 p. Paris, E. FLAMMARION. 1924. Price 7,50 francs.

This volume in Professor ROULE's series of biographies of the great French naturalists is devoted to the outstanding and initial figure of one of the most brilliant of epochs of the development of natural history. GEORGE LOUIS LECLERC, or Count BUFFON (1707-1788) was a Burgundian of a good heritage, disciplined in his youth by a scholarly mother, travelled as a youth with HINCKMAN, a botanist, and interested in his early years in mathematics, mechanics, forestry, statistics, and philosophy. His intellectual facility and social gifts soon brought him into the intellectual circles in Paris and to membership in the Academy of Sciences at the early age of twenty-six. His early writings included a *Traité des fluxions* (NEWTON), an Arithmetique morale, and a translation of HALES' *Vegetable Statics*. He early exhibited great powers of observation, an inclination to compare and to measure, and a philosophical mind. His capacity for sustained and controlled work was tremendous.

These qualities made possible his writing the great *Histoire Naturelle*, the creation of the Museum of Natural History, and the expansion of the little garden of medicinal plants of which he became the Intendant into the world famous Jardin des Plantes. BUFFON also had a fine literary style noted for its charm and lucidity. This fact, together with the widespread interest in natural phenomena prevalent in Parisian circles of his time, tended to give his *Histoire Naturelle* a prestige which placed it in the front rank of works on natural history for a century and led to many editions and translations of the work. Another and very important reason for the intellectual success of his work was the fact that he envisioned both a cosmos and a scale of being. He changed natural history from mere cataloging to a logical display and turned attention from the *lusus naturae* to the grand spectacle of Nature as a whole. In this respect he may justly be regarded as the greatest of all naturalists, in spite of the fact that he was not himself a field naturalist or an explorer. He attracted men and materials to himself and to Paris. He did not himself go into far countries for them.

BUFFON looked at nature in time and as a philosopher rather than as a technician. His *Théorie de la Terre* (1746), which forms the first volume of his great work, is a fine example of the synthetic powers of his mind and opens a new epoch in the intellectual comprehension of nature. It presented a masterly array of facts and of conclusions as to their significance. BUFFON's cosmogony is not that of today, but he envisioned the earth in time. His concept was correct, but he lacked the data to estimate the rate of change correctly. BUFFON found in the things of nature and of life that time was the principal actor, that

these things themselves change in succession, and that they are bound together and directed by mutual gradations. His ideas thus open the road for later progress in the concept of evolution.

October 29, 1934. C. A. KOFOID.

Louis Roule.—BERNARDIN DE SAINT-PIERRE *et l'harmonie de la nature*. 242 pp. Paris, FLAMMARION. 1930. Price 12 francs.

BERNARDIN DE SAINT-PIERRE (1737-1814), moralist, aesthete, and biologist, was born in the then new and busy port of Havre in the midst of exotic influences. Trained as an engineer, he found himself temperamentally disqualified for the administrative contacts of the government service. He vagabonded through Holland, Poland, and Germany, and was made Inspector of Fortifications by CATHERINE THE GREAT at St. Petersburg. Failing here he returned to France where his importunities led to his reinstatement, on condition that he enter the colonial service. Fortunately for his future career, he was detailed to the Ile de France (1768-1770) where he was surrounded by the vegetation of the tropics and familiarized himself with the wealth and variety of marine life of the tropical seas. Even more significant was his intimate association with M. PIERRE POIVRE, the governor of the island, and his intellectually brilliant young wife. POIVRE as missionary and explorer had travelled extensively in China and Indo-China, and had become deeply interested in the introduction and acclimatization of tropical plants into the colonies of France with a view of freeing his native land from the Dutch monopoly of the East Indian trade. The botanical opportunities thus afforded in Mauritius were later supplemented in France by his brief (1792) service as Intendant at the Jardin des Plantes and his later herborizations and excursions about Paris with ROUSSEAU. His *Voyage à l'Ile de France* (1773), *Études de la Nature* (1784), and *Paul et Virginie* (1790), had won him such renown that he was chosen to fill the administrative post held by BUFFON; but his more scientific colleagues at the Jardin opposed him, and the infelicities of his temperament unfitted him for the responsibilities of the position.

The dominant philosophy of SAINT-PIERRE was a beneficent providence underlying all nature. His interpretations were anthropocentric, but he was far more analytical than the herbalists, and a keener observer than the naturalists who had preceded him. He was not an encyclopedist, a systematist, nor an anatomist. Professor ROULE awards to him the distinction of a biologist because of his penetrating generalizations, some of which are surprisingly modern in their implications or content. His observations in natural history are pervaded by the idea of the interrelations of organisms, i.e. of ecology. He keenly perceived the

phenomena of adaptation. Although his interpretation was at times ludicrously anthropocentric, he nevertheless anticipated DARWIN in apprehending the survival values of mimicry, symbiosis, and protective resemblances. His observations on colonial corals led him to the formulation of ideas anticipatory alike of the cell theory, and the organismal concept in its more recent formulations. He anticipated the promorphology of HAECKEL in his appreciation of bilateral symmetry and the major axis, and formulated the interrelations of the floating life of the sea before HENSEN invented the term plankton. His seriated chains of mollusks suggest orthogenesis, and his harmonies are comparable to the correlations of CUVIER, and the *finalité harmonique* of CLAUDE BERNARD. His anthropomorphism led to his interest in the distribution of plants and to the concept of a scientific phytogeography. It also led him to propose the utilization of predatory insects and parasitic diseases for the destruction of insect enemies of crops—the first formulation of the idea of biological control. SAINT-PIERRE was thus not only a man of letters and a philosopher, but an initiator of many ideas of modern biology.

May 11, 1934. CHARLES A. KOFOID.

Louis Roule.—CUVIER *et la science de la nature.* L'histoire de la nature vivante d'après l'œuvre des grands naturalistes français, III. 246 p. Paris, FLAMMARION. 1933. Price 9 francs.

Professor ROULE divides his illuminating discussion of the great anatomist (1769-1832) into three parts, his life, his writings, and his basic ideas. He attributes CUVIER's independence, obstinacy, and impatience with opposition, to his racial origin from the mountaineers of the Jura in the province of Franche-Comté; his industry, orderliness, and scholarly habits to his mother's discipline in Latin, drawing, and reading; his powers of leadership to his early and sustained organizing experience in bringing together kindred spirits in intellectual enterprises; his governing philosophy of life and high sense of duty to his youthful teaching in the reformed faith; his extraordinary mental powers to a precocious hydrocephaly from which he early recovered; and his death to a " forme sèche " of cholera. His interest in the place of the sciences in education grew in part from his studies in the history of science, and his rise to administrative positions in education, and later in the Council of State, resulted from his reputation as an organizer and from his remarkable powers of analysis and synthesis, and the clarity and force of his public speech. His seven years' (1788-1795) experience as tutor in Normandy gave him access to the life of the sea; leisure for dissection, drawing, and writing to his comrade PFAFF; and a rare oppor-

tunity to formulate his ideas on the interrelations of structure and classification which later ripened in his two masterpieces *L'Anatomie Comparée* and *Le Règne Animal*.

CUVIER was a modern in his concept of the relationships of anatomy of the entire organism to classification, and his doctrine of correlation was an adumbration of the control by hormones. His lack of knowledge of embryology and physiology robbed him of the dynamic background and contributed to the defects of his type system of classification, his limitations in palaeontology, and the catastrophism of his geological concepts.

In the face of these biological limitations he left a superbly organized Museum of Natural History, brought classification on to sounder grounds, made palaeontology a science, and associated his name for all time with the significances of the comparative method in the study of animal structure.

May 22, 1934. C. A. KOFOID.

The Lamarck manuscripts at Harvard, edited by WILLIAM MORTON WHEELER and THOMAS BARBOUR. XXXI+202 p., 4 pls. Cambridge, Mass., Harvard University Press. 1933. ($2.50.)

Six holographic manuscripts of LAMARCK are given in the original and translation. The first is an unpublished lecture on GALL's system, which elucidates LAMARCK's interest in anatomy and pathology. The second comprises two articles on " idea " and " imagination " respectively, published in 1817 in *Nouveau Dictionnaire d'Histoire Naturelle de* DETERVILLE. The third, on " human knowledge," dates from 1818 and is an outline of his more extended work on the same subject published in 1820. The fourth, " zoological questions," is evidently an unpublished draft dated by LANDRIEUX 1810-1820 during the editing of the Introduction to the *Histoire des Animaux sans Vertèbres* (1816). The fifth manuscript, on " *L'Histoire Naturelle*," is evidently a preliminary draft of a portion of the first edition of the *Histoire des Animaux sans Vertèbres*, written prior to 1816. Nineteen plates accompanied these manuscripts, two of which are reproduced and the places of publication or probable sources of the others are detailed. The sixth manuscript is imperfect, containing an account of a botanical excursion in 1797.

The frontispiece is a hitherto unlisted portrait of LAMARCK originally engraved for THORNTON's *New Illustration of the Sexual System of Linnaeus* (1797-1807) attributed to DAVID, but in reality painted by THÉVENIN and engraved by JAMES HOPWOOD I.

The historical value of these manuscripts is quite overshadowed by the current value to all biologists of the Introduction of 31 pages, which

largely bears the stamp of the biological philosophy and exhibits the incisive style of the senior editor. It contains an evaluation and comparison of the relative merits of the contributions of LAMARCK and CHARLES DARWIN to the concepts of evolution. This comparison is made the more vivid and startling to orthodox Darwinians by its correlations of the respective evolutionary ideas of the two protagonists of transformism with CROOKSHANK's critical analysis of their respective psychological constitutions.

May 9, 1934. C. A. KOFOID.

Pierre Maes.—*Un ami de* STENDHAL. VICTOR JACQUEMONT. (1801-32) Préface de FORTUNAT STROWSKI, de l'Institut. XII+642 p., 12 pls. Paris, DESCLÉE DE BROUWER & Cie., 1934. (30 frs.)

This ninth volume of the collection " Temps et Visages " under the direction of ANDRÉ GEORGE is a sympathetic and interpretative life of the brilliant young French naturalist, VICTOR JACQUEMONT, who fell a victim to liver abscess in Bombay at the very opening of what promised to be a career of exceptional performance as a scientific explorer. Fortunately his letters were so distinctive and spirited as to record the acumen of his intellect and the scientific bent of his mind. They also indicated the range and scope of his activities as a field naturalist of the Museum of Natural History at Paris. The ably compiled bibliography at the close of the volume records and differentiates the many editions and translations of his " Correspondance " from India. This work is particularly significant, since it relates the conditions under which the collections were made on which the subsequently published " Voyage dans l'Inde " (1835-1844) was based. This quarto series contains his scientific journal and the technical botanical and zoological accounts of his collections.

His travels extended from Calcutta across India to the Punjab and up into Cashmere and Tibet. His skill as an explorer and traveller makes his account of peculiar value. It is a French view of India and the Indian scene during an interesting period of British expansion in that country.

In addition to the scholarly list of JACQUEMONT's writings, there is also an iconography, a list of manuscripts, a very full bibliography, and a long index of names.

October 1, 1934. C. A. KOFOID.

V. Gordon Childe.—*New light on the most ancient East. The Oriental prelude to European prehistory.* XVIII+327 p., 32 pl. London, KEGAN PAUL, 1934 (15 s.).

The main purpose of this book is " to illustrate, and if possible vindicate, the principles that must be applied to the study of European prehistory by reference to the richer and better dated material of the proto-historic Orient. If thereby we have enabled workers in the European field to see their special problems in a clearer perspective and have justified the general doctrine of cultural diffusion, its aim will have been attained." (p. 301) The author had published six years ago a synthesis of the new knowledge about *The most ancient East* (1928) but the results of continuous and systematic digging in many countries have been since then so abundant and so startling that it was practically impossible to revise that earlier book; not only have many new facts been found but the whole pattern has been changed, and the book had to be entirely rewritten.

Within little more than half a century our knowledge of antiquity has been deeply modified not only in every detail but in its very essence. SCHLIEMANN's discovery of the treasures of Troy occurred in 1872. Prior to 1895 the record of Egyptian history began with the Pyramids. Then AMÉLINAU and DE MORGAN found the tombs of the First dynasty, while FLINDERS PETRIE found others which were even more ancient. Sir ARTHUR EVANS resurrected the Minoan civilization in 1900. The prehistoric Badari culture of Egypt was revealed in 1924, and the antecedent Tasian culture later still. In that same *annus mirabilis* (1924) Sir JOHN MARSHALL published the relics of Mohenjo-daro (already described by DAYA RAM SAHNI in 1921)—and thus pre-Aryan India " was revealed as the seat of a high urban civilization by 3000 B.C., already linked up with Babylonia and contributing effectively to the formation of that common cultural tradition which we have inherited." (p. XV).

It is out of the question to summarize a book which is itself a summary, but too brief, of a large literature representing the archaeological activities of many scholars. I prefer to illustrate the author's method with the following quotation. Trying to account for the diffusion of culture over the Near East, as far as the Indus valley to the East and across the Mediterranean basin to the West, he makes these remarks among others :

" Much more profoundly would the new demand for raw materials affect the pace and the very mechanisms of diffusion. Egypt, Sumer, and the Indus cities were now clamouring for vast supplies of timber, building stones and ore, for spices and precious stones for the adornment and service of temples, tombs, and public buildings, and for the equipment of artisans and soldiers. The new

industrial cities must enter into closer relations with the world of peasant communities that had been created by the first revolution.

" To some poor communities of farmers or fishers the satisfaction of the new demand opened up new opportunities, fresh means of livelihood to evoke an expansion of the local population. Egypts' need of timber made Byblos a city... The Egyptians consorted thither as traders, not as conquerors, bringing alabaster vases, jewelry, and perishable goods in exchange for the cedars of Lebanon. Some probably settled; in any case they paid prolonged visits. They taught the Giblites the Egyptian hieroglyphic script and introduced the cult of some Egyptian gods. Egyptian sculptors eventually came to execute the bas-reliefs for the local temple. Byblos thus became a new seat of industrial and commercial life with its own demand for metals and precious stones; the satisfaction of that demand would make it a new focus for diffusion.

" At the same time the new civilization preserved native elements and blended with Egyptian ideas those proper to Asia. Under the very temple that Egyptians had decorated was laid a foundation deposit, a practice foreign to Egyptian ideas but characteristically Babylonian.

" The early rise of urban civilization in Crete is doubtless the result of similar factors, though here colonists from Egypt and Asia contributed to the transformation of a ' neolithic ' culture. And the same sort of thing may have been happening in Anatolia, along the coasts of the Persian Gulf and farther east. In Cappadocia even before the expeditions of Sargon we read of merchants, apparently Assyrians or Babylonians, settled as a colony in charge of the metal trade with Mesopotamia..." (p. 285).

... " Finally, the warlike incidents of the second revolution provoked migrations. In the Early Minoan civilization of south Crete, Egyptian inspiration is so profound and comprehensive that only an actual settlement of Egyptian colonists among the neolithic Cretans (who themselves may have been akin to the Merimdians) will explain it. EVANS suggests that people from the Delta, fleeing before MENES' conquest, had sought refuge on the island. Similarly in the Cyclades we meet early in the third millennium pictures of ships flying the fish standard; the same ensign had been borne by boats from the Delta depicted on Gerzean vases, but it disappeared from the Nile before the beginning of history. The Aegean boats may accordingly belong to other refugees from the Delta who settled in the islands as pirates and traders. At the same time the colonists in the islands and (perhaps later) in Cyprus were mainly Asiatic and inspired primarily with the hope of a livelihood in supplying the growing demands of the primary and secondary centres of urban civilization. Even in Crete this Asiatic element was prominent." (p. 288).

The conclusion of all this—I repeat it for the *n*th time—is that the Hellenic culture was the climax of an evolution lasting at least thirty centuries. It is just as unfair to appreciate it without taking that long evolution into account, as it is unfair to appreciate our modern culture without paying attention to the Greek, Roman, and mediaeval preparations to it.

The hundred odd figures of this book are generally well chosen but the legends are insufficient. Very often the dimensions of the objects

are not mentioned, and we are not always told where the originals are kept. The printing of the notes at the end is deplorable.

London, 3409.11 GEORGE SARTON.

Johan Gunnar Andersson.—*Children of the yellow earth. Studies in prehistoric China.* XXI+345 p., 32 pl., 147 fig. London, KEGAN PAUL, 1934. (25 s.).

There are many reasons for calling our readers' attention to this book, though it is not strictly within our field. To begin with it is a magnificent illustration of the growing importance of the borderland between geology and archaeology, that is, between science and history;—and this is of very direct concern to us because our own field—the history of science—is but another borderland of the same kind. In the second place it contains the first complete account of our present knowledge of prehistoric China. That knowledge is still very imperfect, yet immeasurably superior to that of ten years ago, when it was almost inexistent. Finally it describes in plain language the most important palaeoanthropological discovery of our time, that of the " Peking man " made in 1929. Moreover, it includes an abundance of other materials among which every naturalist, archaeologist and sinologist is bound to discover something of value to his own studies.

The author, later director of the Geological Survey of Sweden, was appointed in 1914 mining advisor to the Chinese government. He is thus primarily a geologist but he became an archaeologist by force of circumstances, and has now to his credit great archaeological discoveries as well as geological and palaeontological ones.

The Chinese have been using fossil bones (" dragon bones ") from time immemorial for medical purposes. In 1899, a German naturalist, K. A. HABERER, went to China and purchased in the apothecary shops of Shanghai, Ningpo, Ichang and Peking a large collection of " dragon bones " and " dragon teeth", and this material was the subject of an elaborate memoir by Professor MAX SCHLOSSER of Munich : Die fossilen Säugethiere Chinas (*Abhdl. bayer. Ak.*, Bd. 22, 1903). SCHLOSSER was able to distinguish in that strange material no less than 90 mammal forms. ANDERSSON had the idea of tracing those fossils to their original localities, and his successful search led him to the discovery in 1918 of the first Hipparion fauna in China. For further details see his earlier book *The dragon and the foreign devils* (Boston, 1928), or chapter 5 of the present volume.

The discovery of *Sinanthropus pekinensis* is even more fascinating. In 1918, ANDERSSON began the exploration of a cave at Chou k'ou tien, n the Western Hills near Peking, and in 1926 his Austrian collaborator,

OTTO ZDANSKY, recognised in the material obtained from it a molar and a premolar of human type. ANDERSSON indorsed that diagnosis. On Dec. 2, 1929, the first *Sinanthropus* skull was discovered by the Chinese geologist W. C. PEI and the anatomical study of all this material was masterly completed by DAVIDSON BLACK (died March 15, 1934), professor at the Peking Union Medical College. That discovery made considerable stir in palaeontological circles, for human remains of the early Pleistocene are exceedingly rare (as opposed to those of the Neanderthal type which belong to the middle Pleistocene). Outside of *Sinanthropus*, we have thus far only *Pithecanthropus erectus* discovered by EUGEN DUBOIS in 1891-2 at Trinil in Java, the *Palaeanthropus heidelbergensis* discovered in 1908, and the *Eoanthropus dawsoni* discovered in 1911-12 by Sir CHARLES DAWSON at Piltdown in Sussex.

Says the author (p. 122) " The earlier finds of pre-Neanderthal hominidae in Java, in Southern England and near Heidelberg seem poor to us now beside the spate of new and fundamental discoveries which, since 1926, have been made in this wonderful cave deposit near Peking : a number of teeth, several jaws, two complete and several fragmentary skulls of the actual *Sinanthropus*, a number of implements formed by him and traces of the fires with which he roasted his bag of large mammals. And in addition the cave deposit is dotted with tens of thousands of more or less fragmentary bone remains of the for the most part extinct animals which this early Chinaman hunted."

According to BLACK, *Sinanthropus* had in his wrist an *os lunatum* similar to that of *Homo sapiens* but unlike that of the anthropoid apes; on the other hand his foot deviated more from the modern type than did his hand.

Before 1923, our knowledge of prehistoric China was restricted to the PUMPELLY's reports, to the fantastic reports of the Chinese and to very few objects (e.g., the so called oracle bones) which could not be understood without knowledge of their environment. In 1922, two French Jesuits, EMILE LICENT, founder of the Huang ho-pai ho museum in Tientsin, and PIERRE TEILHARD de CHARDIN of the Institut catholique of Paris discovered undisputable relics of palaeolithic culture in the Ordos desert, and described their discovery " Le paléolithique de la Chine " in *L'Archéologie*, 1925.

In 1921, ANDERSSON discovered the first prehistoric (late neolithic) village of China in Yang Shao tsun, Mien chih district, Honan, and he described it in his memoir " An ancient Chinese culture " (*Bull. Geol. Survey of China*, 1923). The painted ceramics of Yang Shao are comparable to those discovered at Anau, Chinese Turkestan by RAPHAEL PUMPELLY in 1903-04 (1) and to those of Southern Russia of the Stone-

(1) RAPHAEL PUMPELLY (1837-1923) : Explorations in Turkestan, expedition

Copper age (Tripolje ceramics). A strange feature of that culture (not yet satisfactorily explained) was the existence of pockets into the substratum of Tertiary red clay (p. 171): "These pockets are 1.9-2.8 metres in diameter, circular in form and their present depth varies between 0.5 and 1.9 metres." They are comparable to the *Kellergruben* of neolithic dwellings in Alsace, and also, strangely enough, to the *cache-pits* of an Indian village near Madisonville, Ohio.

In 1922, this discovery was completed by one even more startling—I would be tempted to call it one of the greatest archaeological discoveries of our time: the existence not only of shards but of a large number of very beautiful neolithic painted pots in the T'ao Valley (Kansu). It is hard to imagine that these magnificent examples of the potter's art (bearing comparison with similar ones of the Near East) were unknown before 1922, for they can now be admired in almost every important collection of Chinese ceramics. My wife and self had been deeply interested in them for many years (2), but in spite of our preparation, we were almost taken off our feet when we saw ANDERSSON's astounding collection (hundreds of specimens of every type, twelve shown as *in situ* in the Pien Chia Kou grave, see pl. 30) at the University of Stockholm (the other half of the same collection being in Peking). To indicate the importance of that discovery it will suffice to say that it added a new chapter not only to Chinese prehistory, but also to the history of Chinese art, and of art in general.

A great many of those precious pots were brought to the author during his residence at the provincial capital Lanchow, but he finally managed to find some of the cemeteries from which they had been plundered, and hence to determine their general origin with certainty. An important cemetery was located near the town of Titao, a Muslim district, on the western bank of the T'ao Ho; many others of the late stone and the bronze ages were investigated in the same valley, and finally ANDERSSON discovered others still on the very tops of the P'an Shan hills (2.200 m.) dominating that valley. After having read the fascinating account of those discoveries one can appreciate the author's proud conclusion (p. 271):

"Just as the T'ao valley with its confusing maze of prehistoric sites will certainly one day in the future be regarded as one of the foremost fields of prehistoric research in the world, ranking with the rich sites of the Eastern Mediterranean,

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of 1904. Prehistoric civilization of Anau (2 vols, Washington, Carnegie Institution, 1908).

(2) My wife had for a time no less than twenty two of them in her keeping, which are now unfortunately dispersed in various American and Canadian museums.

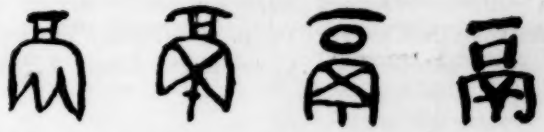
the Nile valley and the river areas of the Tigris and the Euphrates, so also we may say without the least exaggeration that the P'an Shan district, with its five cemeteries high up on the hill-tops, is one of the most magnificent burial-places left to us by prehistoric peoples. It is true that the graves were here invisible beneath their grass covering when the great spoliation began in the spring of 1924. No giant megalithic structures bore witness here to the industrious and virile people slumbering in the windswept graves. But in the majestic free situation of the cemetery, as in the perfect modelling of the burial urns and the finished beauty of their decoration, following inexorable laws of design, these burialplaces are perhaps without parallel in the history of the human race."

Chapter XII (p. 200-24) dealing with "Ancient instruments and vessels" will be of special interest to students of primitive technology, as well as to historians of ceramics. Comparisons with modern Chinese usages are sometimes very helpful. The author discusses the very long clay vessels of the Yan Shao culture, vessels with a sharply pointed bottom (as are often found in the Near East). One of those Chinese prehistoric vessels is almost a meter long, the thickness of the wall being only 5 mm. (p. 219, pl. 20). The *li-tripod*—one of the most typical Chinese forms—was probably created by the junction of three vessels with pointed bottoms (p. 221) :

"It must always have been a standing problem for the ancient families at Yang Shao Tsun to place their pointed vessels so that they would not fall over. The man who discovered the idea of joining three vessels into one solved that difficulty for all time. But at the same time he made a still greater discovery. When it was a question of using the clay vessels as cooking utensils the low conductive power of the pottery must always have presented a difficulty. This inconvenience was to a great extent overcome by the new construction, which made it possible to cook in the legs and to put fuel between them. If to this we add the fact that the surface was enlarged by being made rough through the carpet pattern, we may with some justice say that the discoverer of the *li-tripod* would have deserved a Nobel prize in physics if he had not lived 5,000 years too early for such a distinction."

In the Bronze age the *li-tripod* "assumed a significant form, as the legs were then shaped like a cow's udders, and thus evidently belong to the fertility magic of agriculture, which seems to be such a strong motive in the Chinese Bronze age." I saw an immense specimen of such a *li-tripod* in the Stockholm museum; I suppose it is the very one referred to at the bottom of p. 221 "so large that a young antelope might have been cooked in one leg, a goose in another and the vegetables in the third."

The development of the Chinese character *li*^{4}* (GILES no. 6894, meaning "a large iron caldron, also read *ko*^{4}*, meaning an earthen pot) illustrates this well.



The first sign is the archaic form, the two middle ones are transitional forms, the last one is the modern one (after KARLGREN).

To return to the painted neolithic ceramics, their decoration had possibly a magical meaning, and three chapters of ANDERSSON's book (XVIII, XIX, XX) are devoted to the interpretation of their symbolism. Two of these chapters are in the nature of ethnological digressions on " fecundity rites, hunting magic and death cult " and on " APHRODITE's symbol," i.e., the cowrie-shell *(Cypraea moneta, C. annulus)* the history of which is exceedingly curious (3); the third chapter contains the application of these views to the interpretation of the P'an Shan pottery. In this part of his work ANDERSSON continues and discusses the work of two countrymen of his, Dr. HANNA RYDH and the eminent Sinologist, BERNHARD KARLGREN.

The book is very pleasantly written and well illustrated with excellent photographs, schematic designs and a fine series of portraits of the main geologists and archaeologists whose work is summarized. It is the right kind of book to give to a young man or woman and thus possibly to awaken a new scientific vocation. For one thing, it suggests many problems which are still unsolved, and are just as stimulating to eager minds as the *terrae incognitae* of the old maps. Here is perhaps the main one of those problems (p. 332) :

" How is it that at the present moment, when we well know of about 40 sites of the Yang Shao period in Northern China, we have not found a single dwelling site which can bridge over the period between the Early Stone age discoveries in the Ordos desert and the much more numerous discoveries of the Yang Shao period? Or, in other words, the Yang Shao period, which is so abundantly represented, itself represents the close of the latest Stone age and perhaps even the beginning of the Metal ages. Why have we never made a single discovery of the actual New Stone age, which is so copiously represented in other parts of the world? "

S. S. Transylvania GEORGE SARTON.
October 20, 1934.

(3) See also on this subject, *Isis* 19, 603. The story of the cowrie shell is fairly well known, but the following fact (quoted on p. 296) was new to me. These shells are entirely absent from the coasts of America, and yet they have been found among the remains of Amerinds, possibly also in a pre-Columbian site. If that fact is correct it raises a difficult problem.

V. Meisen (editor).—*Prominent Danish scientists through the ages.* With facsimiles from their works. 195 p. (University Library of Copenhagen, 450th anniversary). Copenhagen, LEVIN & MUNKSGAARD, 1932.

Quoting from the Preface by SVEND DAHL : " In commemoration of its 450th anniversary the University Library of Copenhagen has published this volume, aiming to give merely a condensed survey of the achievements Danish men of science have accomplished in those studies which the library is intended to serve in particular : Natural science, mathematics, and medicine. The book treats of investigators (none now alive) who have broken new trails by some pioneering work in their special study, or those who have otherwise been standard-bearers in the progress of science—that is, authors who have found or conquered new scientific fields by original discoveries or theories of far-reaching significance."

Each man of science is dealt with by a specialist, and for each we are given the main biographical facts, a brief but clear discussion and appreciation of the scientific achievements upon which his fame is founded, and a facsimile of the title page of his main work or of some other characteristic fragment illustrating his activity. This is excellent, and the book is a model which other small nations would do well to follow. Our only regret, and we are perhaps ungrateful in mentioning it, is the absence of portraits.

The notices are arranged in chronological order, which is the best order in a book of this kind. The only mediaeval authors quoted are HENRIK HARPESTRAENG and PETRUS DE DACIA, and the sixteenth century is also represented by two individuals : TYCHO BRAHE and PETRUS SEVERINUS (PEDER SÖRENSEN), the Paracelsist physician, who died of the plague in 1602. His main work *Idea medicinae philosophicae* (Basel, 1571) enjoyed a better reputation than its obscurity deserved and was the subject of a very elaborate commentary by the Scotch physician WILLIAM DAVIDSON as late as 1660 (reprinted in 1668). It would be too long to speak separately of each notice (they number 45 in all), but it is worthwhile to reproduce here the index by profession :

Anatomists and physiologists :
BARTHOLIN, THOMAS
BOHR, CHRISTIAN
HANNOVER, ADOLPH
JACOBSON, LUDWIG
PANUM, PETER LUDVIG
STENO, NICOLAUS
WINSLÖW, JACOB BENIGNUS

Astronomers :
BRAHE, TYCHO
PETRUS DE DACIA
SCHUMACHER, HEINRICH CHRISTIAN

Botanists :
BORCH, OLUF
JOHANNSEN, WILHELM

Örsted, Anders Sandöe
Schouw, Joakim Frederik
Vahl, Martin
Warming, Eugenius

Chemists :
Borch, Oluf
Kjeldahl, Johan
Thomsen, Julius
Zeise, William Christopher

Geologists and palaeontologists :
Forchhammer, Johan Georg
Johnstrup, Johannes Frederik
Lund, Peter Wilhelm
Steno, Nicolaus

Mathematicians :
Mohr, Georg
Petrus de Dacia
Wessel, Caspar

Physicians :
Bang, Bernhard
Bartholin, Erasmus
Bartholin, Thomas
Berger, Christian Johann
Bohr, Christian
Borch, Oluf
Fibiger, Johannes
Finsen, Niels
Hannover, Adolph
Harpestraeng, Henrik
Jacobson, Ludwig
Lange, Carl
Meyer, Wilhelm
Panum, Peter Ludvig
Saxtorph, Matthias
Severinus, Petrus
Steno, Nicolaus
Winslöw, Jacob Benignus

Physicists :
Bartholin, Erasmus
Lorenz, Ludvig Valentin
Örsted, Hans Christian
Römer, Ole

Zoologists and Biologists :
Abildgaard, Peter Christian
Fabricius, Johann Christian
Fabricius, Otto
Hansen, Emil Christian
Johannsen, Wilhelm
Lund, Peter Wilhelm
Müller, Otto Friedrich
Örsted, Anders Sandöe
Petersen, C. G. Johannes
Schiödte, Jörgen Christian
Steenstrup, Japetus

Danish men of science who were still alive when this book was edited and published were wisely excluded. Thus we find no notice in it of the illustrious biologist Johannes Schmidt (1877-1933) who died a year later. For a clear appreciation of his great work, the solution of the mysteries connected with the life of eels, read L. Joubin's article in the *Revue des deux mondes* (July 15, 1934, 401-23). This omission suggests that it will be well to publish from time to time new editions of this excellent book brought up to date.

This first edition beautifully got up is a credit to the publishers as well as to the editor and authors. The firm of Levin & Munksgaard has already placed itself in the forefront of European publishers; it will suffice to recall its magnificent collection of facsimile reproductions

of the mediaeval Icelandic MSS. The present volume will help a larger public to understand the greatness of small Denmark, and incidentally will call its attention to this enterprising firm which has already done so much for the diffusion of Danish culture.

London 3409.08. GEORGE SARTON.

Albert Einstein.—*Comment je vois le monde*. Traduit par le Colonel CROS. VI+258 p. *(Bibliothèque de philosophie scientifique)*. Paris, ERNEST FLAMMARION, 1934 (12 frs.)

Il est regrettable que cette sélection des écrits et déclarations publiques d'EINSTEIN n'ait pas été faite avec plus de soin au point de vue bibliographique : il eut été si facile d'ajouter la source exacte, ou les circonstances, et la date de chaque extrait. Cette réserve faite l'ouvrage est fort précieux; il nous prouve que M. ALBERT EINSTEIN n'est pas seulement un des plus grands mathématiciens de notre temps, mais aussi un vrai grand homme, aussi magnanime qu'intelligent.

Les quelques citations suivantes serviront à illustrer sa physionomie morale :

« Voici à quoi je pense chaque jour fort souvent : ma vie extérieure et intérieure dépend du travail de mes contemporains et de celui de mes ancêtres et je dois m'efforcer de leur fournir la même proportion de ce que j'ai reçu et que je reçois encore. J'ai besoin de mener une vie simple et j'ai souvent péniblement conscience que je demande au travail de mes semblables plus qu'il n'est nécessaire. J'ai le sentiment que les différences de classe sociale ne sont pas justifiées et, en fin de compte, reposent sur la violence; mais je crois aussi qu'une vie modeste est bonne pour chacun, pour le corps et pour l'esprit. » (p. 8).

« Les idéals qui ont illuminé ma route et m'ont rempli sans cesse d'un vaillant courage ont été le bien, la beauté et la vérité. Sans le sentiment d'être en harmonie avec ceux qui partagent mes convictions, sans la poursuite de l'objectif, éternellement insaisissable, dans le domaine de l'art et de la recherche scientifique, la vie m'aurait paru absolument vide. Les buts banaux que poursuit l'effort humain, la possession de biens, le succès extérieur, le luxe, m'ont toujours, depuis mes jeunes années, paru méprisables. » (p. 9).

« La plus belle chose que nous puissions éprouver, c'est le côté mystérieux de la vie. C'est le sentiment profond qui se trouve au berceau de l'art et de la science véritables. Celui qui ne peut plus éprouver ni étonnement ni surprise est pour ainsi dire mort; ses yeux sont éteints. » (p. 12). « Je ne veux pas et ne puis pas non plus me figurer un individu qui survive à sa mort corporelle : que des âmes faibles, par peur ou par égoïsme ridicule, se nourrissent de pareilles idées ! il me suffit d'éprouver le sentiment du mystère de l'éternité de la vie, d'avoir la conscience et le pressentiment de la construction admirable de tout ce qui est, de lutter activement pour saisir une parcelle, si minime soit-elle, de la raison qui se manifeste dans la nature. » (p. 13).

Mais j'aime au-dessus de tout cette remarque aussi claire et nette qu'un théorème de géométrie :

« *La vraie valeur d'un homme* se détermine en examinant dans quelle mesure et dans quel sens il est parvenu à se libérer du Moi. » (p. 16)

M. EINSTEIN est à la fois un démocrate et un individualiste passionné.

« Je suis convaincu », nous dit-il, « qu'un système autocratique de coercition ne peut manquer de dégénérer en peu de temps : en effet, la coercition attire toujours des hommes de moralité diminuée et je suis également convaincu que, de fait, les tyrans de génie ont comme successeurs des coquins. » (p. 10). Et un peu plus bas : « Pour moi, l'élément précieux dans les rouages de l'humanité, ce n'est pas l'État, c'est l'individu, créateur et sensible, la personnalité; c'est elle seule qui crée le noble et le sublime, tandis que la masse reste stupide de pensée et bornée de sentiments. »

Il se rend bien compte que le but de la vie humaine ne peut être pleinement réalisé que s'il est possible aux travaux désintéressés de prospérer.

« Cette prospérité exige tout d'abord une certaine aisance qui met une fraction de la population d'un pays en état de travailler à des choses qui ne sont pas d'une utilité immédiate pour l'entretien de la vie. Il faut, en outre, que le sens de la valeur des traditions morales et des productions intellectuelles de la civilisation reste vivant dans les couches de la population qui travaillent pour les besoins immédiats de la vie, afin qu'elles offrent aux autres la possibilité de vivre. » (p. 100).

Tout cela ne suffit pas cependant; la civilisation est une chose d'autant plus délicate qu'elle approche davantage de la perfection, et qui ne peut exister que si elle est constamment défendue et si ses héritiers restent dignes d'elle et en deviennent de plus en plus dignes.

« Autrefois les hommes ont pu croire que les progrès intellectuels et ceux de la civilisation n'étaient pas pour eux autre chose que les fruits du travail de leurs devanciers dont ils avaient hérité et qui leur fournissaient une vie plus aisée et embellie. Mais les épreuves plus dures de notre époque ont montré que c'était là une illusion néfaste.

Nous voyons que les plus grands efforts doivent être faits pour que cet héritage soit non pas une malédiction, mais une bénédiction pour l'humanité. Si jadis un homme avait de la valeur au point de vue social quand il se libérait dans une certaine mesure de l'égoïsme personnel, on doit maintenant exiger de lui qu'il triomphe de l'égoïsme national et de l'égoïsme de classes. En effet, c'est seulement lorsqu'il aura atteint ce niveau supérieur qu'il contribuera à améliorer le sort de la société humaine. » (p. 107).

D'autres extraits des écrits de M. EINSTEIN nous font connaître ses opinions sur la politique et le pacifisme, l'Allemagne nouvelle, le Judaïsme, et la science. M. EINSTEIN n'est pas un historien, mais il est clair qu'il a fait de grands efforts pour comprendre la pensée de ses devanciers et en expliquer la genèse, et ces explications du génie scientifique par

un homme de génie sont extrêmement précieuses. Ses notes sur H. A. LORENTZ et ARNOLD BERLINER ne nous apprennent pas grand chose, mais celles relatives à KEPLER, DESCARTES, NEWTON, MAXWELL, RIEMANN sont vraiment très utiles et tous les historiens s'occupant de ces personnalités feront bien de les étudier. Les notes consacrées à la relativité ne sont pas de l'histoire, mais plutôt des documents historiques de tout premier ordre. En effet elles nous aident à comprendre la psychologie de l'invention, bien que l'auteur se défende de pouvoir nous aider beaucoup.

« Si vous voulez apprendre des physiciens théoriciens quelque chose sur les méthodes qu'ils emploient, je vous propose d'observer le principe suivant : ne pas écouter leurs paroles, mais vous en tenir à leurs actes. Car à celui qui crée, les produits de son imagination paraissent si nécessaires et naturels qu'il ne les considère pas et ne voudrait pas les savoir considérés comme des inventions de la pensée, mais comme des réalités données. » (p. 163).

Le bateau de FLETTNER lui inspire la réflexion suivante.

« L'histoire des découvertes scientifiques et techniques nous enseigne que l'humanité est pauvre en idées originales et en imagination créatrice. Même quand les présomptions scientifiques extérieures en faveur de la naissance d'une idée existent depuis longtemps, il faut le plus souvent une cause extérieure pour qu'elle se réalise; l'homme doit, pour ainsi dire, buter sur la chose avant que la réflexion vienne. » (p. 248).

J'ai eu bien souvent l'occasion de me faire à moi-même la même remarque, mais elle est singulièrement impressionnante dans la bouche d'un des hommes les plus originaux et les plus révolutionnaires que le monde ait connu.

Pour finir je voudrais encore citer deux extraits fort typiques sur la nature de la pensée mathématique et ses rapports avec l'expérience.

« Avant de nous attaquer au problème de l'espace, faisons tout d'abord une déclaration sur les idées en général : les idées se rapportent aux expériences des sens, mais elles ne peuvent jamais en découler logiquement. Pour cette raison, je n'ai jamais pu saisir la question de l'*a priori* au sens de KANT. Dans les questions de réalité, il ne peut jamais s'agir que d'une chose, c'est de rechercher les caractères du complexe des expériences des sens auxquelles se rapportent les idées. » (p. 216)
« Les concepts mathématiques utilisables peuvent être suggérés par l'expérience, mais non pas en être déduits en aucun cas. L'expérience reste naturellement l'unique critérium de la possibilité d'utilisation d'une construction mathématique pour la physique; mais c'est dans la mathématique que se trouve le principe véritablement créateur. A un certain point de vue, je tiens aussi pour vrai que la pensée pure est capable de saisir la réalité, comme les anciens y ont songé. » (p. 169).

Heil EINSTEIN ! GEORGE SARTON.

Hermann Weyl.—*The Open World* (Three Lectures on the Metaphysical implications of Science). v+84 p., Yale University Press, New Haven, 1932. (Price $1.50).

—. *Mind and Nature*, VI+100 p. University of Pennsylvania Press, Philadelphia, 1934. (Price $1.50).

To one who has struggled with the searching contents of these profound treatises, *Raum, Zeit, Materie* (1918) and *Gruppentheorie und Quantenmechanic* (1928), it is quite apparent that no one has a better right to metaphysical speculation than HERMANN WEYL. In the two small books under review, there is presented by this author a veritable pageant of ideas invoked by discoveries in recent physics. Many old problems of philosophy are reopened and subjected to the interpretation of the findings of modern science.

The lectures which are comprised in the first volume were delivered at Yale University under the auspices of the Dwight Harrington Terry Foundation, and those in the second at Swarthmore College under the William J. Cooper Foundation. The chapter headings of the first volume are God and the Universe, Causality, Infinity, of the second, Subjective Elements in Sense Perception, World and Consciousness, Constructive Character of Scientific Concepts and Theories, Relativity, Subject and Object in Quantum Physics. It is thus evident that the two sets of lectures are closely correlated and supplement one another.

The domain which the author attempts to explore is essentially the metaphysical character of nature. He is interested primarily in the problems of teleology and epistemology, particularly as these problems are affected by recent discoveries in the fields of relativity and the theory of light quanta. In the introduction to the first volume he sets his theme: "Modern science, insofar as I am familiar with it through my own scientific work, mathematics and physics make the world appear more and more as an open one, as a world not closed but pointing beyond itself."

In the first lecture the author gives a brief history of the concept of diety from the *νοῦς* of PLATO through the concepts given by DANTE's *Divina Commedia* to the concepts of the modern world as they have been modified by scientific thought. He compares the cosmology of ARISTOTLE in its rigid framework with that of DANTE which, he avers, "has been reestablished by EINSTEIN for entirely different reasons, the doctrine, namely, that three-dimensional space is closed."

Contrasting the concept of God "as the infinite in perfection" with man in his finiteness, the author envisages mathematics as the bridge by which man under "the Faustian urge" presses forward toward a comprehension of this perfection. "We witness here a strange occur-

rence, unique in the history of philosophy; the exactness of mathematics is sought not for its own sake, nor as a basis for an explanation of nature, but to serve as a foundation for a more profound conception of God."

Into such a picture there naturally intrudes the concept of the ether. How is it to be understood? In view of the apparent demise of this elusive entity under the attacks of recent physical speculation, one reads with much interest the following words: "And to present-day natural philosophy it is still a profound enigma, to my mind *the* deepest mystery with which it is confronted, how this powerful predominance of the ether in its interaction with matter is to be understood."

The author nowhere attempts to define deity in terms of physical attributes. To him apparently this concept is embedded in the depth of natural mysteries. "Therefore the structure of space behaves with regard to things as one would naturally imagine the behavior of an absolute God toward the world; the world is submitted to his action, but he himself is beyond the influence of any action from the world." Perhaps it is fair to estimate that the author's concept is not far from the Absolute Ideal of HEGEL, which lies at the end of a long series of antinomies that limit forever man's apprehension of it.

We find the author again enunciating the common theory that "in a law of nature... simplicity is essential." The sense in which the word *simple* is used may, perhaps, be open to question. This postulate regarding simplicity in nature was formulated when KEPLER showed that the comparatively elementary conic sections were able to replace the complicated epicycles of PTOLEMY in the description of the motion of the planets. The theory was more firmly established when NEWTON interpreted the laws of KEPLER by means of his simple postulate regarding gravitation. But, in spite of these elementary ideas, the mathematical structure of celestial mechanics is extremely complex, as one may see by examining the 170-page equation by means of which DELAUNAY attempted to describe the motion of the moon. We cannot forbear to quote from *The Life of the Spider* by HENRI FABRE upon this point: "What a quantity of abstruse science for a bit of string! Let us not be surprised. A pellet of shot swinging at the end of a thread, a drop of dew trickling down a straw, a splash of water rippling under the kisses of the air, a mere trifle, after all, requires a titanic scaffolding when we wish to examine it with the eye of calculation. We need the club of Hercules to crush a fly." Perhaps this picture is nearer to the truth, in spite of the fact that we have had so much success in the description of nature by means of differential equations of second order.

Turning to the problem of causality, the author asserts that there are

two components mingling in the idea " the mathematical concept of determination by law and the metaphysical notion of the reason for something ", but he reaches the interesting conclusion that " the law of nature offers as little evidence for or against a metaphysical-teleological interpretation of the world as it does for or against a metaphysical-causal one." The problem of reversibility naturally intrudes in a consideration of any postulate of determinism in nature and he shows the dominating rôle of probability here by contrasting a reversible mathematical time with a subjective time which always flows from the present to the future. Reviewing the dilemmas of the quantum theory with their pointings toward an indeterminism in nature, the author concludes with a defense of the *Gestalt* philosophy that " the whole is more than the sum of its parts." He finds in the atomic structure of nature " that the state of a system consisting of two electrons determines the states of both electrons, but the converse does not follow. The knowledge of the states of the two parts of a system by no means fixes the state of the whole system."

In dealing with the infinite that author reviews four attempts to describe the continuum : first, the attempt to describe it in terms of countable discrete elements after the philosophy of DEMOCRITUS; second, the infinitesimal theory which underlies the early history of the calculus and its limiting process; third, the theory of sets; fourth, the attempt of HILBERT to throw the logical difficulties of the continuum back upon a consistency embedded in a formalistic structure of symbols. He arrives at five conclusions : (1) that there are two domains in man's life, one of creation and another of reflection; (2) that the task of science is not sufficiently performed through intuition, but requires action. " Truth must be attained by action." (3) The infinite is accessible only as a field of possibilities. (4) The infinite as a " realm of absolute existence " is closed to the human mind. (5) The mind, in its demand for totality and " belief in reality," inevitably must represent an infinite by " symbolic construction."

In his second volume the author attempts to find out how far the subjective element is present in our knowledge of the world. In this he might be characterized as adopting almost a BERKELEYian point of view as one may apprehend from the statement : " The structure of our scientific cognition of the world is decisively determined by the fact that this world does not exist in itself, but is merely encountered by us as an object in the correlative variance of subject and object."

The author develops what he calls " the correspondence theory of our knowledge of reality " which is aptly epitomized by the aphorism of HERACLITUS : " The Lord whose oracle is at Delphi neither reveals

nor hides, but announces by tokens." That is to say, the objective world which lies behind our subjective knowledge of nature can never be anything but a symbolic construction and in the words of HERTZ " we neither know, nor do we have means to find out, whether our representations of the objects have anything in common with the objects themselves except that one fundamental relation (of concordance) alone."

He arrives at the conclusion that " constructive cognition "has three essential features : (1) attributes inherent in things are recognized by invariability in symbolic construction; (2) judgments are split up by isolates attained through the use of symbols; (3) symbols are " embedded into an ordered manifold of possibilities created by free construction and open towards infinity."

The volume concludes with short descriptions of the theory of relativity and the present status of the quantum theory, both of which have obviously made a profound impression upon the philosophy of the author. Thus, for example, his symbolic construction of knowledge is a natural outgrowth of the doctrine of the relativity of perception which he illustrates by noting that, since sunlight is 150,000 times as intense as moonlight, white paper in the latter is darker than black velvet in the former, and yet we see paper as white in each light.

From the brief description of these two books which has been given above, it will be seen by the reader that the reviewer has had an impossible task. In the small compass of two hundred pages the author has surveyed most of the great problems of epistemology in the light of modern physical discovery. To review an epitome of so large a field makes this an epitome of second order, and justice cannot thus be done to all the rich ideas set forth by Dr. WEYL.

Indiana University, H. T. DAVIS.
Bloomington, Indiana.

Morris R. Cohen and **Ernest Nagel**.—*An introduction to logic and scientific method*. XII+467 p. New York, HARCOURT, BRACE, 1934 ($3.50).

The authors have set before themselves three aims to be striven for in the composition of the book. First, they purpose " to bring some order into the confusion of tongues, concerning the subject matter of logic "; to discharge the function of a " mediator " or " peacemaker " " between hostile points of view." Secondly, they aim to remedy " the unimaginative way logical principles have been taught and misused " by combining " sound logical doctrine with sound pedagogy." Thirdly, they wish to provide rich illustrative material from all the manysidedness of our modern life exhibiting the energizing of logic " in every department of thought " (preface).

After a preliminary chapter on the nature, subject matter and use of logic, the authors take up, in the first half of the book, the general study of the elementary principles of formal logic, treating such traditional topics as the nature, analysis and relations of propositions, the nature and kinds of syllogisms and the nature and significance of modern mathematical logic. In the second part of the book, logic is taken up in its intimate relevance to scientific method, and such topics as measurement, hypothesis, induction, probability, experimentation and statistics are dealt with. There are in this second part two other interesting chapters on the value of logic in historical inquiry and in critical evaluation.

As an elementary introduction to the meaning and function of logic in civilized activity, this book is quite valuable. It is intended to introduce its subject to college students, but it may very profitably be read by the general reader. The style is lucid, the problems treated are, though elementary, yet very interesting, and the whole book is suffused with concrete everyday illustrations drawn for the most part from the distinctive life of the present generation. No educated man should find the least difficulty in going through the whole book.

The book confessedly does not aim to be exhaustive of the subject matter it treats. Thus we may not with fairness judge it on this score. There are a few matters, however, which arose in our mind as we read the book, which it would not be amiss to point to here. The authors develop the conception that logic has to do with the grounds and criteria of validity (pp. iv, 7, 13, 27, 34, 110). All logical distinctions are thus shown to subserve ultimately this concern of logic (see particularly p. 46). But there is a wider conception of logic, of which the authors do not seem to be unaware, which views logic as the systematic study of pure possibilities of structure. This conception includes the authors' conception as a special case of itself, because the systematicity of a given structure may not be brought about exclusively by the internal relation of "implication." After all, "implication" itself is a structure, and must give an account of itself in terms of a more general conception of structure. The emphasis that the authors seem to lay on truth and truth-values is quite foreign to logic thus widely conceived, for, if complications of "truth" belong essentially to logic, then the authors are under obligation to elaborate a doctrine of truth, which, however, is completely missing in their work. We feel, furthermore, that another allied defect in almost all extant texts of logic is their reference at critical points to the question of interpretation of abstract systems without giving an adequate metaphysic of the possibility of such interpretation (see following places where our authors come up against the problem of interpretation without giving it any serious attention: pp. 126, 130,

137, 392). Either logic has nothing to do with " interpretation," wherefore no *critical* mention of it should be made in works on logic, or, if it has to do with " interpretation," you cannot as a logician possibly feel that you have discharged your obligation towards your subject by merely mentioning, as it were casually, that such and such abstract systems do receive such and such actual exemplifications.

In two places (pp. 51 and 125) the authors could have abstracted, without great psychological damage to the type of reader they were having in mind, into more generalized structural formulations. Abstraction into diverse types of propositional structure and propositional relations can be carried out before the student as a sample of logical abstraction, and the student's imagination then left to itself to recoil from, or to crave for more, such abstraction.

There is one " specific subject matter " (p. 135) to which every set of assumptions, no matter how pure, refers, and that is the subject matter of human consistency of meaning. The authors throughout presuppose a Kantian-Peircian sensationalism (see especially pp. 137 and 218) which maintains that " subject matter " is by nature sensuous. This is a dogmatic presupposition. Every set of postulates presupposes a sense of multiplicity, of discreteness, of maintenance of meaning, of symbolic inter-reference. And for logic, this sense is itself the subject matter of all that logic talks about.

The authors are scientific positivists. Their chief positivistic article of faith is that science is the savior of the world. By science they mean the scientific discipline and the cumulative material outcome of such discipline. The scientific method, we are told (p. 392), solves all " the problems which meet us in daily life." Scientific procedure is depicted as the chief real agency for " uniting man " (p. 403). We challenge the truth of both these positions. There is abundant evidence that, far from solving all our solvable daily problems, science is increasingly adding to our scientifically unsolvable concrete problems. We are not referring to any abstract dogmatic position. We are merely referring to whether the authors in all honesty believe that the actual vital daily perplexities of our modern man have increased or decreased. Furthermore, do our authors have any ground for believing that the future, in so far as it shall be an expression of science, shall see a decrease in these perplexities?

As to what the authors mean by the statement that " scientific procedure unites men," we must confess we do not know. What they mean, we may guess, is speculative union, not real concrete union. Everybody knows enough irritable and ununitable scientists to subscribe too readily to the authors' cheerfulness. Prior to science, there is always the scientist.

No disciplined withdrawal into the safeties of scientific speculation will ever relieve the world of the concrete manhood of its scientists. If there is any philosophic point to science, it is this, that it is that agency in the world which, by its very nature, does *absolutely nothing* to "unite men." Sources of concrete unity are to be sought for elsewhere than in science.

There are several good features to the book. Its questions and exercises on each chapter at the end of the book are excellent. We feel that the text of the book is not sufficient but should be supplemented with the good suggestions for further reading given at the end of the book. Excellent also is the authors' introduction of several of their discussions with classical literary selections. It is good to establish, the way the authors do, a sense of conversational informality between author and reader. There is a good summary criticism of Aristotelian logic (p. 111); a good elementary discussion on the "self-evidence" of axioms (p. 131); a good discussion on the nature of probable inference (p. 157); a very good discussion on the dangers and fallacies of the use of statistics, to be recommended to all statistical fiends (p. 316); a very good discussion of diverse abuses to which the scientific method is liable (p. 382). The concluding chapter of the whole book may serve as an elementary introduction to the meaning and function of science in modern civilization.

October 1934. CHARLES MÂLIK.
Cambridge, Mass.

Ulysses Prentiss Hedrick.—*A History of Agriculture in the State of New York.* Printed for the New York State Agricultural Society. Geneva, N. Y. XIV+462 pp., 82 pls., 41 figs. in text, 2 maps. 1933. Price $3.00.

This is a history of agriculture in rural New York from the period of Indian occupation to the end of the nineteenth century. It includes both the social and scientific phases of this basic form of human culture in one of the most typical regions of temperate North America during one of the great periods of transition during which agriculture was mechanized, transportation enormously expanded, agriculture and horticulture greatly diversified, and the social and industrial relations of the farmer widely interwoven into an ever more and more complex civilization by the discoveries of science. This history is written by the Director of one of the foremost Agricultural Experiment Stations in the U.S.A., that of New York State, at Geneva, N. Y. It therefore reflects the skilled observations of an agricultural expert, the matured judgment of an analytical mind long familiar with the changing scene of agriculture, and the synthetic powers of a scientist seeking to interpret

the forces shaping rural human culture under the impact of scientific discovery.

The book opens with an account of the primitive forest and a critical summary of what is known of Indian agriculture, which included the culture of maize, tobacco, potato, beans, pumpkins, squashes, gourds, sunflower, and artichoke. They made a " wink-tippling " drink of *Ilex cassine*, related to the maté of South America. The only domesticated animal they had was the dog, which was used as food. The author lists 73 plants used by the Indians as food and in industry. The only fruit grown was the black plum. Horses evolved on the American continent but none were living here when CORTEZ introduced the Arabian horse from Spain. This animal was used by the plains tribes but had not reached New York.

The author reviews the land policies of the colonial period; the European and other sources of the agricultural legacy of New York; the national migrations peopling it; the growth of agricultural organizations and of the supplemental sustaining industries; the succession of turnpikes, waterways, and railways; the paraphernalia of the rural home and the farmer's folkways; the contributions of the Puritans, Quakers, and Huguenots to the religious background and the aberrant communal forms of religion arising in the rural regions such as the Shakers, Millerites, Harmonists, Mormons, and Spiritualists. The relation of the press to rural culture and development is also outlined. The rapid development of farm machinery and its effects on rural economy are admirably traced and illustrated. Of especial value is the historical account of the changes in cereals, livestock, and fruits due to the developments of the biological sciences, and to the more empirical methods of the agricultural experiment stations in the earlier years of their operation for the improvement of agriculture. The history of State and Federal aid to the farming industries in New York is an epitome of this movement in the United States, a pioneer among the nations in the field of State aid to the sciences basic to agriculture.

This work is a source book of unusual value. It is splendidly illustrated with reproductions from early works and has quite a list of historical sources. It is outstanding as a comprehensive summary of the use of modern scientific agriculture in the United States.

September 24, 1934. CHARLES A. KOFOID.

Lewis Cecil Gray.—*History of Agriculture in the Southern United States to* 1860. Assisted by ESTHER KATHERINE THOMPSON. With a foreword by H. C. TAYLOR. Carnegie Institution, Washington. In two volumes. Vol. I, XXI+7-567 pp., 1 map; Vol. II, X+568-1086 pp., 12 figs. in text, 1933. Price $7.25.

This work is the result of research for more than twenty years of the rural economy of the Southern States of the U.S.A. during the period in which their agriculture, and, in fact, their entire economy was based on slavery. There was an additional unification in the fact that the major crops, tobacco and cotton, were rather widely distributed throughout the area to which slavery was limited, and within which the plantation system developed, the first large scale organization of agriculture since the days of the Roman Empire.

While primarily economic in purpose, aim and content, this monograph deals critically with the social and industrial aspect of human slavery as well as with its relation to subsistence farming and domestic industry, its economic strength and weakness, and the conflict of the farmer and merchant classes, resulting from the plantation system.

The work is replete with analyses of the constituent classes of the South, the organization of its social life, the plantation system and the slave trade, both internal and external. It is a scientific and historical account of the way of life of a fairly unified, quite extensive, and long established agricultural community of a high racial status during a period of expansion and rapid change due to the advances in civilization resulting from scientific discoveries.

It deals with the development of a national economy as affected by the American Revolution and the readjustments consequent upon independence, by the land policy and tenure during the westward expansion, and by the changes in the supply of slave labor resulting from internal expansion and external restriction of the slave trade, and the economic disadvantage of slavery to the South as a whole.

The treatise is amply documented, has a bibliography of twenty-four pages, an appendix of statistical tables, and a very full index.

September 24, 1934. CHARLES A. KOFOID.

E. G. R. Taylor.—*Tudor Geography*, 1485-1583. XII+290 p., 16 fig. London, METHUEN & CO., 1930 (15 s.).—*Late Tudor and Early Stuart Geography*, 1583-1650. XIV+322 p., 8 fig. London, METHUEN & CO., 1934 (15 s.).

The publication of these two volumes indicates that the history of science in England during the sixteenth and early seventeenth centuries is beginning to receive the truly thorough study it so richly deserves.

Hitherto, scholars interested in the mediaeval period have rarely carried their researches beyond the beginning of the fifteenth century, while those dealing with the modern period have begun, as a rule, with the founding of the Royal Society. Consequently, the intervening two hundred years, which witnessed the most important stages of the gradual transition from mediaeval to modern science, have been only imperfectly and superficially known. Therefore, Miss TAYLOR's two books, covering the progress of the science of geography in England from 1485 to 1650, are of particular significance, and cannot be overlooked by any student of the history of science. They represent the first attempt to give a genuinely comprehensive survey of the extant literature of any of the mathematical sciences for the period of the English Renaissance.

The great English voyages and colonizing projects of the sixteenth and seventeenth centuries have often been discussed either as great adventures of discovery, or as incidents in a program of maritime expansion; Miss TAYLOR, who is Professor of Geography in the University of London, for the first time recreates the scientific background of these voyages. She emphasizes the part that contemporary scientists played in accumulating the data essential to the intelligent planning of the various expeditions, and shows that it was not through mere chance that these voyages made real contributions to the growing body of accurate scientific knowledge.

Inasmuch as geography draws upon most of the other mathematical sciences, especially geometry, surveying, astronomy and navigation, the principal contemporary works in these subjects are included by the author in her discussion. Thus the work takes on a wider scope than its title indicates, and tends to become a bibliographical survey of all the books written or published in England during the period, which relate to any of the mathematical sciences. The method of presentation adopted is appropriate to this type of study. The comprehensive bibliographies of English works on geography and related sciences, arranged chronologically, are designed to be one of the most important features of the work, and take up over one third of the space in each volume. The chapters in the text constitute a commentary on the more significant titles listed in the bibliographies, with occasional sections dealing in greater detail with subjects or individual scientists of outstanding importance.

Tudor Geography, 1485-1583, first published four years ago, is by far the better of the two volumes. Its first two chapters are devoted to an excellent general survey of English geographical literature during the period, emphasizing the change that took place after 1550, when the English search for the passage to Cathay began. Before that date, the published geographical works consisted mainly of the mediaeval encyclo-

pedias, epitomes of the writings of the classical authors, and popular handbooks derived from these sources. From 1550 onward, however, the English were engaged in a systematic effort to acquire and make their own the best existing knowledge in the geographical sciences, from the recent works of Continental writers. Furthermore, as the English mastered the new knowledge, they put it to the test of practise, and corrected and augmented it, in accord with their own experience.

From 1550 to 1583, by far the most important figure, from the scientific point of view, was JOHN DEE, and Miss TAYLOR devotes three subsequent chapters to a detailed discussion of DEE's geographical work. This is the most significant section of the book, and the first adequate appraisal of DEE's place in the history of English science. Most accounts of DEE have dwelt upon his later career, when his efforts were turned to the fruitless pursuit of the mystical lore of astrology, alchemy, and crystalgazing. This, however, was not the period of DEE's great influence, and Miss TAYLOR is to be congratulated on restoring JOHN DEE to his rightful place as the central figure in the beginning of modern science in England. Through his close friendship with the greatest scientists on the Continent (the author points out that the five most eminent contemporary geographers, PEDRO NUÑEZ, GEMMA PHRYSIUS, GERARD MERCATOR, ABRAHAM ORTELIUS and ORONTIUS FINAEUS, were among his intimate friends and correspondents) JOHN DEE, and through him, his English pupils and fellow-workers, were kept in constant touch with the latest scientific developments in Europe. DEE's own library, containing the most important scientific works, both ancient and modern, was without a rival, and was always at the disposal of his friends. Add to this DEE's work as the chief scientific advisor to the principal English voyages to 1583, and his acknowledged eminence as an inspiring teacher, and his supremely significant rôle in Elizabethan science becomes obvious.

Other chapters which make a real contribution to our knowledge of the period are the one on ROGER BARLOW and his *Brief Summe of Geographie*, and the final chapter, tracing the development of practical surveying instruments in England, from earlier Continental models. At the end are four valuable appendices. The first is the catalogue of English geographical and kindred works, arranged chronologically, and including both printed books and manuscripts, although the list of manuscripts does not pretend to be complete. Although a number of important printed books were omitted from this list, nearly all of these were included in the addenda to this bibliography, printed in Miss TAYLOR's second volume. JOHN DEE's geographical works are recorded in a second appendix, and this is succeeded by a catalogue and bibliography of contemporary libraries, made up from four lists; namely,

those of the libraries of JOHN DEE and Sir THOMAS SMITH, of the library formed by the Earl of ARUNDEL and JOHN, Baron LUMLEY, and the bibliographical list printed by PURCHAS in 1614. As an illustration of the scientific works available and familiar to English scholars during the period, this list is invaluable. A final appendix reprints extracts from various illustrative documents.

On the whole, *Tudor Geography* is a work of sound and thorough scholarship, and by far the most important book yet published dealing with Elizabethan science. Except for a defect in the plan of the author's bibliographies, which, since it applies to both volumes, will be discussed later, only two erroneous statements require notice. On p. 54, discussing BARLOW's " Regiment of the North Pole," the author says :

> The guiding stars (called ' guards ') are not the pointers, but the three stars in the handle of the Dipper, i.e. ϵ, ζ and η in Ursa Major. Their successive positions, corresponding to Barlow's figure, are given roughly in Fig. 4.

The figure shows eight positions of the stars of the Dipper. It seems surprising that Miss TAYLOR should make such a mistake in identifying the " guards," for in all sixteenth century writers on navigation they are clearly designated as the stars β and γ of Ursa Minor. In her edition of BARLOW's work, printed by the Hakluyt Society in 1932, Miss TAYLOR has fortunately corrected this serious error. The other mistake is a comparatively trivial one. On p. 15, RICHARD BENESE's surveying instrument is wrongly described as a line four perches long, instead of five perches.

The author's *Late Tudor and Early Stuart Geography*, 1583-1650, recently published, is decidedly inferior to the earlier volume to which it is a sequel. The period it covers, though shorter in years, is vastly greater both in the amount and the variety of its works dealing with geography. A study of this material, equal in thoroughness to her *Tudor Geography*, would have required far more time and space than Miss TAYLOR has given to it. Consequently, the text of this volume is little more than a sketchy and disconnected running commentary on the bewildering number of books listed in the bibliography, with, at the end of each chapter, a reference, by number, to several additional titles unavoidably passed over in the discussion. Nevertheless, the book has brought together such a store of miscellaneous information about the geographical writings of the period that it is certain to be of great value to scholars, particularly in suggesting lines of approach to more detailed studies. The chapters likely to prove most useful are those on HAKLUYT and PURCHAS, on mathematical geography, navigation and surveying, on regional and human geography, and the two chapters

on economic geography. The latter should be of special interest to presentday readers, in the light of current attempts at National Planning.

The inaccuracies in this volume are more numerous than in the first, the consequence, no doubt, of hastier writing. JOHN SMITH's *Sea-Grammar*, for example, is not his *An accidence... for young seamen* under a new title, as stated in both text and bibliography, but a new work, of about three times the length of the latter, although using some of the same material. Likewise, the dates of the first printed edition of TREVISA's English translation of BARTHOLOMAEUS ANGLICUS' *De Proprietatibus Rerum* (1495), and of BUCHANAN's poem, *De Sphaera* (1584; with PINCIERO's additions, 1585), are incorrectly given as 1471 and 1587 respectively. In the bibliography many works of outstanding importance have unaccountably been left out. Notable among these are the treatises on the invention and development of logarithms, by NAPIER, BRIGGES, SPEIDELL, GUNTER and WINGATE, and the works on trigonometry, such as HANDSON's translation of PITISCUS, and the books of SPEIDELL and GUNTER. The value of these mathematical works to geography and navigation was emphasized from the first by their authors, and problems illustrating their practical application in these sciences were in some cases inserted. Yet the only books on these subjects included by Miss TAYLOR are NATHANIEL ROE's *Tabulae logarithmicae* and RICHARD NORWOOD's *Trigonometrie*, both acknowledged by their authors to have been compiled from the works of their more eminent predecessors.

The most fundamental criticism of Miss TAYLOR's two books, however, has to do with a serious defect in the plan of her bibliographies, which has made them practically useless to all other scholars, except as lists indicating the number and variety of the geographical and kindred writings of the period. In addition to books and manuscripts now extant, she has, for sound enough reasons, included works known only from contemporary references, but she has failed to distinguish these untraced works in her bibliographies. She must have realized, certainly, that those using her book would be interested not only in the fact that a certain treatise existed some three hundred years ago, but would also wish to know whether it still existed, and where a copy might be found for further study. Yet one will usually search in vain for this latter information in Miss TAYLOR's volumes. Had she merely devised a simple set of symbols for the principal libraries in England, and a symbol to indicate the titles no longer extant, she could have made this essential knowledge available to other scholars, and the increase in the cost of publication, if indeed any at all, would have been insignificant in comparison with the advantages gained. For English printed books, of course,

this information could well have been omitted, for the location of copies of the extant works can readily be traced through Messrs. POLLARD and REDGRAVE's *Short-Title Catalogue*, an invaluable work to which Miss TAYLOR makes ample acknowledgment of her indebtedness. With books not listed in the *Short-Title Catalogue*, however, the question arises as to whether they are works no longer extant, or are books that were printed on the Continent, and the author gives us no clue to the answer. The difficulties are multiplied many times when one has to do with the manuscripts listed, for there is no union catalogue of the manuscripts in English libraries. Thus the reader is confronted with the task of searching through several dozen volumes of manuscript catalogues, all the while being uncertain whether or not the manuscript he is looking for is still extant. Even though Miss TAYLOR felt obliged to omit full designations of all manuscripts by library, collection and number, she might easily have spared others the necessity of repeating the laborious search for documents she had already gone through. She need only have indicated the extant manuscripts by inserting after the entry a symbol indicating the library or collection in which it was to be found. (The symbols used in the *Short-Title Catalogue* might be suggested as a model.) Had she done no more than this, Miss TAYLOR would have made her bibliographies of real and lasting value to other scholars in the field of Elizabethan science. As they stand, however, these bibliographies are far more annoying than useful.

The Huntington Library. FRANCIS R. JOHNSON.

R. E. Dickinson and **O. J. R. Howarth.**—*The making of geography* IV+264 pp., 5 pls., 30 figs. (Oxford, The Clarendon Press.). 1933. ($3.00).

This is a history of the progress of geographical science from its beginnings among the Sumerians and the Egyptians down to its latest concepts of natural environments or regions as elaborated by HERBERTSON. Dr. HOWARTH writes of ancient and mediaeval geography and Mr. DICKINSON has dealt with the period from the sixteenth century to the present. Trade advanced geographical knowledge but sought to restrict its spread. The travelling Greek philosophers did more than the trading Phoenicians to round out the knowledge of the circum-Mediterranean world, but trade joined hands with the urge for exploration as culture advanced, especially in the sixteenth century, to define and map the real world. The authors trace the growth of scientific concepts of geography. The Moslem world by virtue of its extension and unification built up a practical knowledge of regions, routes, and rest-houses and embodied them in gazeteers including even China and Korea.

The Caliph AL-MAMUN had the works of MARINUS, and PTOLEMY translated. The circumference of the earth was recalculated by them and degrees measured with an error of only three degrees between Toledo and Baghdad. The Arabs introduced from the east and perfected the planispheric astrolabe and used it in determining astronomical altitudes, calculating latitudes, time, and the heights of mountains. From this instrument was adapted the navigators' astrolabe used by COLUMBUS and not superseded till the middle of the 18th century.

Dr. DICKINSON credits VON HUMBOLDT and KARL RITTER with the founding of modern scientific geography in the physical and human fields respectively. RATZEL in Germany and LEPLAY in France bridged the gap between these two schools, influenced largely by evolutionary ideas derived from DARWIN. Biogeography also derives its significance from the evolutionary aspects of geographical changes. The author of the chapter in biogeography states that the old idea that temperature was the main factor controlling animal distribution is exploded and migration is now more important. It is quite probable that both plant and animal ecologists would not accept this view as true in either of their respective domains. Temperature places limits about species both in altitude and latitude and interacts with other factors of history and associations to produce the existing pattern of life on the earth. The book is a very useful compendium of geographical facts and theories organised as a development of human culture. One defect which runs throughout the work is the lack of an adequate consideration of the sea as something more than a highway for ships, in relation to the physical, regional, biogeographical, and cultural aspects of geography.

July 10, 1934 CHARLES A. KOFOID.

George C. Homans and **Charles P. Curtis, Jr.**—*An Introduction to* PARETO: *His Sociology*. 299 pp. New York, A. A. KNOPF, 1934. ($2.50)

This brief analysis of VILFREDO PARETO's *Trattato di Sociologia Generale* constitutes the first fruits of a seminar conducted at Harvard University by Professor L. J. HENDERSON. Those familiar with Professor HENDERSON's seminar will recognize the acknowledged source of many of the illustrative materials, especially those on scientific method, which crowd the pages of this *Introduction*. Particular emphasis is laid upon the conceptions of MACH, POINCARÉ, and of "operationalism" (BRIDGMAN) as exemplified in PARETO's analysis of social phenomena. Numerous examples of scientific procedure in mechanics, chemistry and biology are cited to point the way for a truly scientific study of society.

Imbued with a frank enthusiasm for the *Trattato*—"PARETO may

be the COPERNICUS of sociology"—the authors indulge in respectful derogation of other sociologic analyses. The indictment of extra-Paretian sociology includes charges of over-logicality and sentimentality: "professional sociologists" do not take sufficient account of the preponderating rôle played in social life by the non-logical actions of man. Incidentally, this book occasionally furnishes us with unwitting illustrations of the pervasiveness of the non-logico-experimental elements. (*E.g.*, the statement that "people usually become sociologists precisely because they hold such strong sentiments about the questions it [sociology] studies" (p. 144) is proffered with no experiential validation.)

The discussion of the significance of PARETO's methodology is generally more illuminating than that by BOUSQUET, but the latter's more critical attitude on certain points—for example, static social equilibrium—warrants continued attention. In their analysis of the "residues," the authors fall heir to PARETO's own ambiguity: the term "residue" is used to refer to uniformities in men's statements and actions as well as to sentiments. Such usage, as a cursory operational analysis will indicate, makes for confusion.

Numerous illustrations of "residues" and "derivations" are culled from contemporary literature, law, mythology and politics to indicate the convenient applicability of PARETO's conceptual scheme. The authors advisedly make no effort to criticize the *Trattato*, but rather, in dulcet, Shavian fashion, present an adequate, simplified exposition of its content.

This book establishes a new high mark in the popularization of PARETO's sociology and we may rest assured that the forthcoming English translation of the *Trattato* will be welcomed by the intellectuals who deem PARETO — to quote from the jacket of the *Introduction* — "as significant to the world... as KARL MARX and OSWALD SPENGLER."

Harvard University. ROBERT K. MERTON.

Eugene Freeman.—*The categories of* CHARLES PEIRCE. 62 p. Chicago, Open Court, 1934.

The author attempts to give "a compact and organized conspectus" of PEIRCE's categorical doctrines. As a result of his logical studies, PEIRCE came to the conclusion that human conceptions are ultimately governed by three categories, to which he applied the colorless names, Firstness, Secondness and Thirdness. PEIRCE defends the ultimacy, ontological reality and mutual irreducibility of these three categories. Firstness is something like immediacy; Secondness something like real interaction between two ontologically equally real entities; Thirdness something like relational mediation between two entities. What PEIRCE wants to say is that the real necessarily involves its own self-immediacy,

its real interaction with other reals and an element of representative generality whereby a diversity of reals is mediated into some preservative unity. In this little book Mr. FREEMAN discusses this doctrine of PEIRCE and its grounding in PEIRCE's logical and philosophical theories. Mr. FREEMAN displays a good grasp of PEIRCE's thought, but he does not seem to be sufficiently critical of the philosophical adequacy of this thought. For instance, he does not seem to feel uncomfortable over PEIRCE's sensationalist and rationalistic presuppositions. But there are good discussions of PEIRCE's famous theories of tychism and synechism, and of the role of these theories in PEIRCE's philosophy. There is also a good schematism of PEIRCE's categories (p. 57) in which Mr. FREEMAN tabulates under the three fundamental categories their diverse manifestations in human experience.

Cambridge, Mass. CHARLES MÂLIK.
October, 1934.

A. W. Wakil.—*The third pandemic of plague in Egypt.* Historical, and statistical epidemiological remarks on the first thirty-two years of its prevalence. Publ. No. 3, Faculty of Medicine. Egyptian University. 169 pp., 26 charts, Cairo, 1932.

Plague has ravaged mankind since before history began and has done much to modify the course of history by the extermination of human families, by checking the progress of civilization, and by deflecting trade and human migrations. The civilization of Egypt, both ancient and modern, has afforded unique facilities for this epidemic since its agricultural interests foster rats and its semi-arid conditions favor fleas, while the absence of sanitary control made possible the rapid spread and serious results of the disease. Egyptian commerce in this melting-place of the East and the West also spread the disease to other contiguous and even more distant lands. Medical progress, and possibly a decline in violence, seem to have reduced the severity of its ravages since the days when the Egyptian botch and emerods threatened the Israelites, and field mice and sudden death routed the army of SENNACHERIB from the Egyptian city of Pelusium. RUFUS OF EPHESUS refers to plague as especially prevalent in Egypt. It is not certain that all pandemics of the past called plague were due to *Bacillus pestis*, but three such pandemics generally referred to as due to true plague have occurred in the Christian era. The first originating in Egypt in 542 A.D. is known as the plague of JUSTINIAN. The second was called the Black Death because of pneumonic complications, and reached its zenith in 1347 A.D., spreading over Europe and the known world. The third pandemic, which still lingers, started in China near the end of the 19th century.

Since the trade from the Orient converged in Egypt, and diverged thence throughout Europe, Egypt came to be regarded as the perennial source of plagues, which probably travelled with cargo in fleas, rats, and humans.

Plague was not restricted, however, to the pandemic periods. After the Arab conquest it appeared in epidemic form in the 7th and 8th centuries, but disappeared until 1010 A.D., reappearing later with the Turkish invasion in the 11th century, became violent during the Crusades, and culminated in the pandemic of the Black Death in the 14th century. In 1072 A.D. Cairo was a desolate city of the dead. In 1201 and 1296 the terror returned, and in 1348 the Black Death arrived from the Italian Republics, when 900,000 deaths occurred in Cairo, industry and agriculture all but ceased, and even domestic animals shared the fate of their unhappy owners. Epidemics recurred in 1373, 1443, and 1459. In these, as in the earlier ones, the violence was reported by historians and physicians to have been very severe, in this respect differing notably from the milder form of the disease in the present pandemic. HIRSCH reported 21 epidemics of plague in Egypt between 1783 and 1844.

But plague vanished from Egypt in the second half of the last century, due, in the opinion of the author, to change in trade routes, England's interests in India, the Suez Canal, and sanitation (1). Plague, however, abates in the absence of sanitation in response to the laws of epidemiology summed up in herd immunity, but is stimulated into activity by various environmental factors, with the result that secular cycles emerge.

The paper deals mainly with the details of the present pandemic, tracing its origin, spread, results, and epidemiology.

September 6, 1934. CHARLES A. KOFOID.

(1) On Egyptian sanitation with reference to the Muslim pilgrimage, see Dr. DUGUET (Paris, 1932; *Isis* 20, 499-503).

Proceedings of the Eleventh Annual Meeting of the History of Science Society

Washington, D. C. December 28 and 29, 1934

REVISED STATUTES

1. This Society shall be called The History of Science Society. Its purpose shall be to encourage and to maintain an active interest in the history of science in general and of the various sciences in particular.

2. The officers shall be a president, two vice-presidents, a treasurer and corresponding secretary, and a recording secretary.

3. There shall be a Council consisting of the officers, the chief editor of the official journal, the chairman of the committee on publications, ex-presidents of the Society, and fifteen other members. The Council shall have general charge of the affairs of the Society.

4. The president and vice-presidents shall be elected by ballot for two calendar years; five members of the Council shall be elected by ballot at the annual meeting for a period of three calendar years. An official ballot shall be sent to each member at least one month prior to the annual meeting. Each ballot shall contain a name proposed by the Council for each vacancy, with blank spaces in which the voter may substitute other names. A majority of all votes cast either in person or by mail shall be necessary to election. In case of failure to receive a majority vote for any office, the members present shall choose by ballot between the two having the highest vote. The corresponding secretary and treasurer and recording secretary shall be elected annually by the Council.

5. All ex-presidents of the Society shall be ex-officio permanent members of the Council. For the president and vice-presidents the term of office shall be for two years or until the incumbent's

successor is elected. In case of a vacancy in any office, the Council shall elect a member of the Society to fill the vacancy until the next annual meeting.

6. Persons elected as members of the Society by the Council shall be admitted upon payment, within sixty days of the date of election, of the first annual dues (five dollars). Libraries and other institutions of learning are eligible to membership without vote. A member failing to pay his dues within sixty days of notification shall be considered as having withdrawn. Members elected during the year of organization (1924) shall be designated as Foundation Members.

7. The official journal of the Society shall be sent without charge to each member. It shall contain reports of the meetings and such other materials as shall be of interest to members of the Society. The chief editor of the official journal shall be a member of the Council ex-officio.

8. There shall be a Committee on Publications of five members, to deal with publications of the Society other than the official journal. This committee shall be appointed by the Council, and its chairman shall be a member of the Council ex-officio.

9. The annual meeting of the Society shall be held in December of each year, the precise date and time to be determined by the Council. Other meetings may be called as the Council may direct. The Council shall meet at the annual meeting of the Society and may be called together or consulted by mail at the president's option.

10. These statutes may be amended by letter or in person, by a two-thirds vote of the total membership of the Council.

REPORT OF THE PROGRAM
WASHINGTON MEETING, DEC. 1934

Program of the Eleventh Annual Meeting of The History of Science Society in joint session with the Fiftieth Anniversary Meeting of the American Historical Association and The Washington-Baltimore Section of the History of Science Society was held December 28 and 29, 1934 at the Mayflower Hotel, Washington, D.C.

The first joint session of the above organizations was held in the Pan American Room Friday, December 28 at 2:30 P.M. with President HARVEY CUSHING of Yale University presiding. The first paper of this program was by Dr. DOROTHY STIMSON, Dean of Goucher College, Baltimore, on Puritanism and the New Philosophy in Seventeenth Century England. Following Dr. STIMSON's remarks, Dr. S. E. MORISON of Harvard University discussed the paper. The second paper was by Dr. SANFORD V. LARKEY, Medical School of the University of California, San Francisco and the discussion was taken up by Dr. CUSHING. The last paper for the afternoon was an illustrated and informal discussion of the Origins of Modern Cartography, 1250-1500, by Dr. DANA B. DURAND of Harvard University. The discussion of this paper was taken up by Dr. L. C. KARPINSKI of the University of Michigan.

The program this year varied from the preceding meetings in that the dinner which followed in the evening was an innovation which it is hoped will become an annual affair. A committee of the Washington-Baltimore Section of The History of Science Society had this matter in charge. Following the dinner the President, Dr. HARVEY CUSHING gave the first annual presidential address, the subject being "The Humanizing of Science." Following this the Editor of *Isis*, Dr. GEORGE SARTON, gave an interesting account of the International Congress of the History of Science held in Portugal during October. This was followed by a paper by Dr. ALEXANDER POGO, staff member of the Carnegie Institution of Washington, on Calendars of Early Civilization. This dinner meeting was a success and we were fortunate in having as distinguished guests, Dr. JAMES H. BREASTED, former president of the Society and Miss BREASTED, Dr. JOHN C. MERRIAM and Mrs. MERRIAM.

The final session of the program took place Saturday morning, December 29 at 10:00 A.M. with Dr. SANFORD V. LARKEY presiding, owing to the illness of Dr. CHARLES A. BROWNE. Dr. GEORGE SARTON gave a very interesting and informal talk on the study of Arabic Science, showing the many avenues open for research in this most interesting period. Following, Dr. JOHN RATHBONE OLIVER, Institute of the History of Medicine, Johns Hopkins University, Baltimore, read a most scholarly paper on Greek Medicine and its

Relation to Greek Civilization. The final paper for the program was given by Dr. RICHARD H. SHRYOCK, Department of History, Duke University, Durham, North Carolina, on The Value of Medical Source Material to the Social Historian. This paper revealed unlimited sources for the future historians in the social, political and economical sciences.

Following are the two committees which had this program in charge :

Program Committee	*Committee on Arrangement*
Dr. HARVEY CUSHING, Chairman	Dr. JAMES F. COUCH, Chairman
Dr. JOHN F. FULTON	Dr. CHARLES A. BROWNE
Dr. LYNN THORNDIKE	Mr. FREDERICK E. BRASCH
Dr. HENRY E. SIGERIST	Mr. MORRIS C. LEIKIND, Secretary
Dr. RICHARD H. SHRYOCK	
Mr. FREDERICK E. BRASCH, Secretary	

REPORT OF THE SECRETARY

TO THE PRESIDENT AND COUNCIL OF THE HISTORY OF SCIENCE SOCIETY :

Herewith, I submit my report as Secretary-Treasurer for the year ending November 30, 1934. Heretofore it has been customary to read the treasurer's report in detail, but several Council members have suggested that this could be condensed and read in brief. A detailed copy of the expenses are on a separate sheet and may be examined by those who wish to do so.

The total number of members to date is 654. The total income for the year 1934 was $2685.00 including the transfer of a small balance from the revolving book fund; the total expense was $2668.75. The largest item of this expense, excluding *Isis*, was $425.00 for secretarial aid, as you will note on the accompanying report. It is the first time in the history of the Society's activities that the expenditure for secretarial aid has reached this amount, and it is because of the increase of work and activities of the Society, which is constantly demanding more time than I personally can give consistently to it. I, therefore, found it expedient in every way to assign the extra work to an assistant. It has become increasingly evident that if the Society

wishes to grow, more and more constructive work must be undertaken. This we have attempted to do throughout the year, and it has resulted in a large increase in membership. You may be interested to know that this office has, for the past year, prepared and mailed over 3,000 letters, including the yearly statements and special invitations. Each item required much thought and preparation. In view of the increasing demand on our Revolving Book Fund by scholars wishing aid in publishing manuscripts, we have transferred a small balance from the book fund to the expense account of the Society, in order to meet the burden placed upon our already heavy correspondence.

The new membership list is nearly ready to be typed, as about ninety-five percent of the postcards have been returned. We hope to have this printed in an early issue of *Isis*, arranged alphabetically and geographically.

The final revised statutes have been approved by members of the Council by mail.

It is most gratifiing to report that letters received from friends and members are constantly commenting upon the high scholarly level of *Isis*. There is every reason to believe that the Society is on its way to greater recognition and if it is to maintain its place in the intellectual life of the world, provisions must be made to further support and encourage this. Since our funds are limited, it is evident that extra means must be secured. This end may be reached by obtaining an endowment fund, and establishing a life membership policy. If we can obtain a membership of 1000, the problem of the expense of the Secretary's office would be solved in part.

The increase of membership is being taken care of by Miss GREENER and me through a plan, demonstrated to be the most successful yet attempted by the Society. As a matter of comparison, I shall outline briefly the two methods so far used. We began our new campaign by sending to the prospective members a specially engraved invitation card signed by the President, inclosing a circular showing the history and activities of the Society. This was followed, in about three days time, by a letter from this office, calling the candidate's attention to the fact that his work has been noted through an article or a book, and stating that the Society might possibly be of further aid to him in his work. We

have prepared approximately 150 cards and letters and have succeeded in obtaining 50 new members, the cost altogether being approximately $100.00. Dr. SARTON, in the early part of the year, canvassed the entire membership list of the fifth edition of "American Men of Science," having an expenditure of $200.00 plus a secretary's salary, and succeeded in getting only about 35 new members. Therefore it is evident, by merely calculating, that it would be less costly to have this office take care of the business of increasing the membership through the special invitation card. I might state at this time that each member of the Council who has the desire to recommend others for membership, should send me the names of his candidates.

The Secretary, last June, visited his old home in California, and was fortunate in being a guest of the most interesting and active group of young historians of science at the University of California. Here in Washington, together with members residing in Baltimore, has been formed a second group of interested scholars, which is active in advancing the history of science movement. The spirit existing in these groups is an omen of the coming times.

FREDERICK E. BRASCH,
Secretary.

TREASURERS REPORT

CASH RECEIVED

Dues from 449 members	$2245.00	
Dues from 1933 (delinquent)	110.00	
		$2355.00
Sale of *Isis*		30.00
Transferred from Book Fund		300.00
Total		$2685.00

EXPENDITURES

Paid to *Isis*	$1884.00
Secretarial Aid	425.00
Printing	84.75
A. C. L. S.	25.00
Railroad Expense	101.00

"Who's Who" (Biographical Dictionary)	8.50
Washington-Baltimore Section Expense	10.00
Postage, telegraph, etc.	50.50
Back Nos. and Advertising	80.00
Total	$2668.75

Total cash received	$2685.00	
Total expenditures	2668.75	
Balance		$ 16.25

Total members	497
Total new members	85
Total delinquent members	48
Total foreign members	65
	695
Deaths and Resignations	41
Present membership	654

FREDERICK E. BRASCH,
Treasurer.

COUNCIL RECORD

Meeting December 28, 1934, 5 *p.m.*

The Council of the History of Science Society met at the Mayflower Hotel, Washington, D.C., with Dr. HARVEY CUSHING in the chair.

Present: Dr. CUSHING, President; Mr. BRASCH, Secretary, Dr. COUCH (representing Dr. BROWNE), Dr. LARKEY (representing Dr. LEAKE), Dr. KARPINSKI, Dr. SARTON, Dr. SHRYOCK, Dr. SIGERIST, Dr. STIMSON; Mr. LEIKIND, Dr. JAMES WESTFALL THOMPSON, Dr. WILLARD, (By invitation); Dr. SIMONS, Recording Secretary.

Minutes of the last meeting omitted.

Committee on dictionary of scientific and medical terms: Discussion

of this matter included offers of cooperation and help from Dr. WILLARD, for some time at work under a grant from the American Council of Learned Societies, on a British-Latin Dictionary, and from Dr. THOMPSON. A motion was then passed: The History of Science Society appreciating the need of a glossary of medieval scientific terms appoints the following committee to study the question, organize systematic investigations, and report at its next annual meeting. Chairman, Dr. HENRY E. SIGERIST; Dr. SANFORD V. LARKEY, Dr. L. C. MCKINNEY, Mrs. D. W. SINGER, Dr. LYNN THORNDIKE, Dr. M. C. WELBORN.

Election of new officers and Council members: The following officers were declared elected for the two-year term 1935-36. For President, Dr. CHARLES A. BROWNE; for Vice Presidents, Dr. CHAUNCEY D. LEAKE, Dr. HENRY E. SIGERIST; for Members of the Council to serve until December 1937, Dr. LOUIS T. MORE, Dr. EDWIN G. CONKLIN, Dr. GEORGE S. BRETT, Dr. HAROLD T. DAVIS. Dr. WATSON DAVIS.

Report of Treasurer-Corresponding Secretary was read and approved.

Report of Editor of Isis: The Editor reviewed the history of *Isis* for the past 10 years. The number of volumes published has been 17, of which 10 are due to the Society, the others to Dr. SARTON himself. This year some 1400 pages have appeared; without vol. XXII, just out, 1008 pages and 21 plates. The devaluation of the dollar has had a serious effect on the real income of the Editor and he suggested an increase in dues. Another suggestion was made that advertisements be added to *Isis*.

Proposal for other classes of membership such as Life Membership. The Corresponding and Recording secretaries were asked to make a study of such memberships in other organizations.

Establishment of Local Branches: Discussion of advisability of this was animated. Suggested that there be an amendment to the constitution to the effect that local groups consisting of at least *five* members of the Society may have the right to apply to the main organization for establishment. *Isis* is to publish soon a list of members arranged geographically and this may stimulate the formation of such groups. No action taken.

Meeting place for 1935: The Society will hold its annual meeting in St. Louis, Mo., in connection with the Christmas

meeting of the American Association for the Advancement of Science.

Resolutions concerning Dr. Wm. H. Welch and Dr. Berthold Laufer: Mr. BRASCH read resolutions expressing the loss to the Society of these members and sympathy for those nearest them, the resolutions concerning Dr. WELCH to be sent to his relatives and those concerning Dr. LAUFER to Mrs. LAUFER.

Delegate to the American Council of Learned Societies: Dr. H. E. SIGERIST. (Dr. LYNN THORNDIKE's term expired in 1934).

Election of Secretaries for 1935 : Mr. F. E. BRASCH was reelected Corresponding Secretary and Treasurer, and Dr. LAO G. SIMONS was reelected Recording Secretary.

Meeting adjourned on motion at 6:30 P.M.

LAO G. SIMONS,
Recording Secretary.

SUMMARY OF *ISIS* ACCOUNTS FOR 1934

For previous account, see Isis 21, 233

Expenditures			*Receipts*		
Printing	3,000.11		HSS dues		1,815.00
Plates & figs.	130.11				
Mailing	752.06	3,882.28	*Sales of back vols.*		
			Bruges	783.15	
Royalties			HSS	139.50	
Reprints	212.83		Brussels	116.32	1,038.97
Other	27.50		C.I.		1,212.25
Gifts	33.36	273.69	N.A.S.		500.00
			Gifts from friends		62.05
Editorial			Adv. (HSS)		50.00
Cambridge off.	423.86				
Brussels off.	352.16	776.02			4,678.27
Insurance		11.63	Editor's add. loss		265.35
		4,943.62			4,943.62

N.B.—This account is not entirely exact as I have not taken into account the continual fluctuations of the exchange. For the sake of simplification Belgian francs have been converted into dollars at the single rate of

1 B. fr. = 4.65 U.S. cents or 1 U.S. dollar = 21.50 B. fr.

Distribution of the expenditures	
HSS (dues)	36.7 %
Subsidies	34.6
Editor	26.4
Friends	1.3
Advertising	1.0
	100.0 %

The editor's final loss $265.35 is the smallest in the history of *Isis*. This is due to the help given by the Carnegie Institution and the National Academy of Sciences without which the loss would have been the largest ever suffered i.e., $1977.60. It should be noted that the generous help is given by the Carnegie Institution not to *Isis* but to the Editor in order to enable him to publish the materials needed for his *Introduction*.

Allow me to draw attention to the fact that the dues paid by members of HSS cover only a little more than one third of the total expenditures. The members have received in 1934 nos. 59 to 62, plus no. 63 to p. 216, a total of 1226 p., 25 pl., 43 fig. containing 32 memoirs, 34 shorter items, 62 reviews and 1914 bibliographic notes, also the index to vols. XIX-XXI. The cost of printing amounted to $2.55 per page (incl. pl. and fig.), the total cost of publication (incl. every expenditure) amounted to $4.03 per page.

G. S.